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The Sponges of Kaneohe Bay, Oahu[1]

M. W. DE LAUBENFELS[2]

THE HAWAIIAN ISLANDS lie near the center of the north tropical Pacific Ocean. The island of Oahu is in the midst of these islands Kaneohe Bay is near the middle of the windward side of Oahu, which side extends from northwest to southeast. The whole bay extends slightly over 11 kilometers along the coast, but is only some 3 kilometers (2 miles) deep. It is sheltered by extensive off-shore coral reefs, however, so that the water in it is much calmer than that of the open ocean. The southeast end of the bay is further sheltered by Mokapu peninsula so that it is here three-fourths landlocked; a roughly circular area some 3 kilometers in diameter is thus especially sheltered. The present study is based upon collections within this latter area which includes the junction of latitude 21° 26′ N. and longitude 157° 48′ W.

The deeper portions of Kaneohe Bay have a sand bottom; practically no sponges occur on sand. There are many patches of coral scattered throughout the bay, coming up to extreme low tide level, thus nearly but not quite 1 meter below the high tide surface. Such masses are often more than 100 meters in diameter, and have a vertical measurement above the floor of the bay of 10 to 15 meters. Much of the outer or fringing area of each is living coral, but the bulk of each mass is dead coral. There are innumerable interstices, and these are teeming with invertebrate life, including sponges. To collect and study this fauna, large armful-sized masses of coral were broken off, hauled to the surface, and placed on a boat where they were broken into small bits by means of hammers and crowbars. It is common to find that 5 to 10 per cent of the surface of the dead coral, down in these narrow crevices, is covered with living sponges. These are, however, always thin, often as thin as paper. Such incrustations are difficult to detach, or to study in any other way.

Much of the study of Kaneohe Bay was conducted at or near the island that has long been known by the Hawaiian name of Moku O Loe, but which has lately been termed Coconut Island. It is less than a kilometer in greatest dimension. Several man-made lagoons about 20 to 80 meters in length and connected to each other, and to the ocean, by channels that are 2 to 8 meters wide, have been constructed. In the channels sponges grow luxuriantly, and an individual sponge colony may quadruple its mass in 1 year's growth. In the calmer waters of the lagoons a few scattered sponges occur, some of rather large size (10 to 20 cm. high), but it is evident that there they grow very slowly; individual colonies showed so little growth in a year's time that it could not be measured. Doubtless there was some growth, but probably less than 10 per cent increase. These larger lagoon specimens are probably several years old, perhaps even 10 years old. Larger sponges in the channels may be only 10 months old.

Field investigation was carried out approximately once a month from September, 1947, to May, 1948 (9 months), and again in

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FIG. 1. Map of the island of Oahu showing Kaneohe Bay and Moku O Loe.

October, 1948. About a dozen species of sponge were found to be fairly common or regular in occurrence in accessible locations, and a second dozen were found, but were rather rare and uncommon. It is certain that continued search would gradually but steadily build up this latter category to a total of at least 2 or 3 dozen. The same amount of effort and time expended on the Pacific coast of the United States, for areas of similar size and placement, would yield just about the same number and average size of specimens. The same may also be said for the coasts of England in particular and northwest Europe in general. In contrast, the Atlantic coast of the United States yields only half as many species, but typical regions in the Mediterranean and in the West Indies yield half again as many species, and the individual colonies are many times larger.

The possible faunal relationships of Hawaiian species to those of other parts of the world are interesting. Of the 23 species here discussed, 12 (or more than half) are new species. Of the 12, 7 (or more than half) are new genera. This is not unexpected in view of the insular location. Of the species that are here identified with previously named forms, four are circumtropical—almost to be called cosmopolitan—two are East Indian, two are from the Pacific coast of Panama, the others are from scattered localities. The two Panamanian forms conceivably may have been brought to Hawaii on ship bottoms; at least one of them is abundant on those that are dry-docked at Pearl Harbor. Conversely, they may have been taken to Panama from Hawaii.

The study of sponges in the field is complicated nearly everywhere by the occurrence of certain species of ascidians of the family Didemnidae which closely resemble encrust-

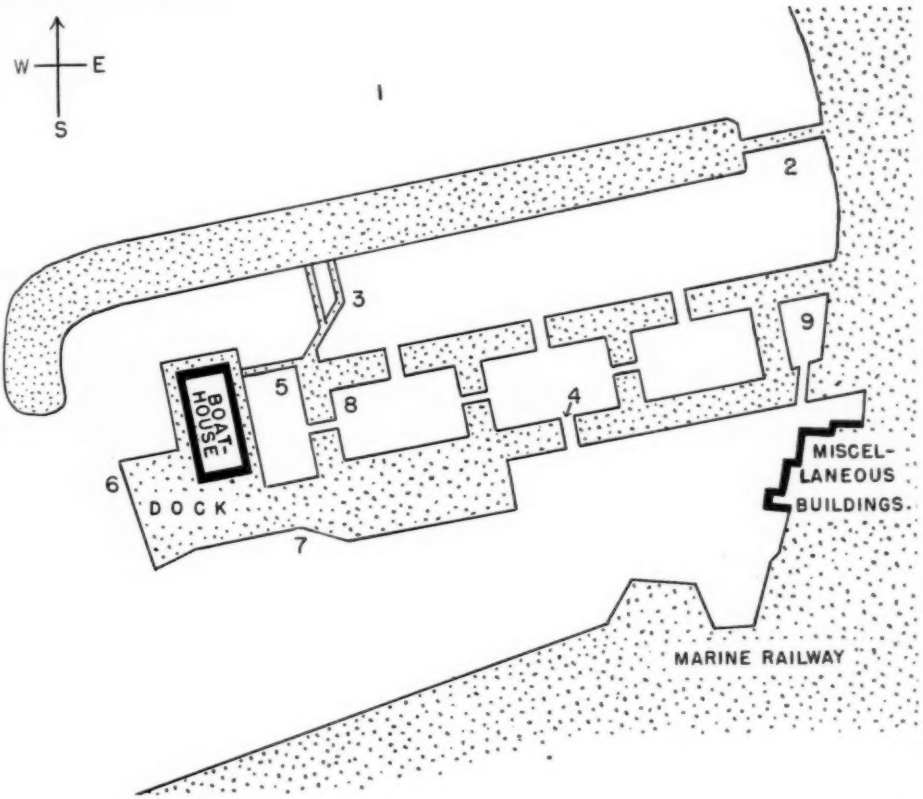

FIG. 2. Map of the vicinity of the Hawaii Marine Laboratory at Moku O Loe, showing by number six locations that are referred to, and three others for future reference.

ing sponges in all respects that are visible to the naked eye. Massive or branching sponges are easily discriminated, but such thin crusts as characterize the coral patches of Kaneohe Bay are perplexing. This locality furthermore contains especially numerous examples of the sponge-mimicking ascidians. The latter even contain spicules of the sort known as spherasters (a central ball, covered with outward projecting, conical, spines). Quite a few sponges contain spicules of just this shape, but these are always siliceous in sponges, always calcareous in the ascidians. Some sponges have calcareous spicules, but these are never spherasters.

A probable identification of the commoner sponges of Kaneohe Bay and vicinity may be made in the field by the key which is furnished below. Positive identification can only be made after microscopical study. Permanent mounts to show structure should be sectioned and preserved in balsam; but there are simpler methods available if permanent mounts are not required. Much structure can be ascertained by use of a dissecting-type stereoscopic microscope. One may slice the sponge in various directions and tease out small bits, using such a microscope. For spicule study one may take bits of the sponge, some from the surface and others from the interior, each bit about 3 mm. in diameter, put a few drops of concentrated fresh sodium

hypochlorite solution on the sample, add a cover slip and study, pressing on the cover slip with a dissecting needle to move the gas bubbles. Commercial bleaching solutions such as Clorox and Purex will do, but a more concentrated solution is preferable. Such a solution destroys the protoplasm and leaves the spicules obscured only by the myriad bubbles. These latter may be moved about so that the isolated spicules are revealed. For permanent mounts one may boil out a sample (on a slide) with about six drops of fuming nitric acid, later adding balsam and cover slip.

A few words about spicule nomenclature may be in order. Megascleres typically make up the framework of the sponges in which they occur and are always comparatively large, sometimes even visible to the unaided eye. Microscleres never make up the framework of a sponge and are almost always minute. Some have a distinctive shape, and when such a shape is found to be large, that spicule is still regarded as being a microsclere in spite of its size. Megascleres may have three or more rays diverging from a central point (triaxon, tetraxon, etc.) or, instead, may be monaxon. The latter may be sharp at both ends (oxeas) or at only one end (style). If rounded at both ends they are called strongyles; if swollen at both ends they are called tylotes. A tylostyle is swollen at one end, pointed at the other. The prefix "acantho" means spiny. Microscleres may be very thin rods (raphides), S- or C-shaped (sigmas), or archer's-bow-shaped (toxas). Some are asters, covered with long rays. These are termed euasters if all radiate from a point, but are called streptasters if the rays radiate from a rod or bar. Amphidisks or birotulates have a circular pattern at each end of a rod. Related forms called chelas are so elaborate that they require illustration; some resemble anchors. If both ends are alike, it is an isochela, but if the ends differ it is an anisochela.

KEY TO GENERA

The commoner species occur in the genera marked with an asterisk.

1. No proper spicules present . . . 2
   Proper spicules present 5
2. Spongin network present 3
   Spongin network absent 4
3. Fibers almost always clear . . . . . **Spongia*** p. 7
   Fibers full of debris . . **Dysidea** p. 9
4. A few fibers present, no network . . . . . **Pleraplysilla** p. 9
   No fibers present, dermal spongin present . . . . **Hexadella** p. 10
5. Spicules of silica present 6
   Spicules of calcium carbonate present 24
6. Spicules rare, skeleton chiefly sand . . . . . **Kaneohea** p. 23
   Spicules common 7
7. Astrose spicules present 8
   Astrose spicules absent 9
8. Sponge spherical, no twice-bent oxeas . . . . . **Tethya*** p. 30
   Sponge not spherical, twice-bent oxeas present . . **Zaplethea** p. 32
9. Some spicules triaxon . **Plakortis** p. 33
   No spicules triaxon 10
10. Ectosomal spicules the same as those of endosome 11
    Ectosomal spicules different from those of endosome 20
11. Larger spicules diactinal 12
    Larger spicules monactinal 15
12. Diacts are strongyles . . . . . **Xytopsiphum** p. 11
    Diacts are oxeas 13
13. A fine-mesh dermal network present . . . . . **Callyspongia*** p. 12
    No such dermal net present . . . 14
14. Spicules oxeas and small toxas . . . . . **Toxadocia*** p. 16
    Spicules oxeas and raphides . . . . . **Neoadocia** p. 15

15. Monacts chiefly styles (a few may have a slight "head") 16
Practically all monacts clear-cut tylostyles 18
16. No spicules except styles . . . . . **Hymeniacidon*** p. 27
Other spicules also present 17
17. Anisochelas and sigmas also present . . . . . **Mycale*** p. 24
Styles, isochelas, anisochelas, sigmas, toxas, and raphides present . . . . . **Zygomycale*** p. 25
18. Spicules only tylostyles; sponge never boring into $CaCO_3$. **Terpios*** p. 28
19. Oxeas and acanthomicrostrongyles also present; sponge usually confined to galleries in $CaCO_3$ . . . . . **Cliona*** p. 30
20. Dermal spicules spiny . **Naniupi** p. 18
Dermal spicules smooth 21
21. Endosomal spicules spiny . . . . . **Myxilla** p. 17
Endosomal spicules smooth . . . 22
22. Microscleres only raphides . . . . . **Tedania*** p. 21
Other microscleres present 23
23. Microscleres are isochelas . . . . . **Damiriana*** p. 13
Microscleres are amphidiscs . . . . . **Hiattrochota** p. 19
24. Spicules chiefly calcareous triaxons . . . . . **Leucetta*** p. 34

DESCRIPTIONS OF SPECIES

Spongia oceania new species

Figs. 3, 4

The holotype of this species is designated as a dried specimen, U. S. National Museum, Register Number 22755. It was collected February 14, 1948, just north of the entrance to Hanauma Bay, from a depth of 8 meters. Further data as to the abundance of this sponge are given after the description.

The shape of *Spongia oceania* is irregularly massive. Its size is often greater than 10 cm. in diameter. As is the rule in this genus, the exterior is normally jet black, the interior brown. Specimens that grow in the shade, however, fail to reveal the black color. The first ones that I found, from Moku O Loe, were dull brown externally, turning gray in alcohol. The consistency is very spongy as compared to other genera, but *oceania* is definitely less spongy than are most other species of the genus *Spongia*.

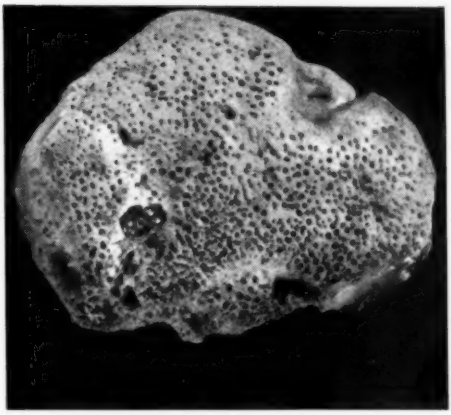

FIG. 3. Holotype of *Spongia oceania*, × ½.

Its surface is most distinctive. Large areas are completely devoid of conules, and where these protrusions do occur they are only 0.1 to 0.2 mm. high, 4 to 6 mm. apart, and are vague. The oscules are 1 to 2 mm. in diameter. In a typical area of 10 square cm. I count 138 oscules; the average will certainly be close to 14 per square cm. on the upper surface of the sponge. There are, of course, very few on the sides, and none below. Many are only 2 mm. apart, center to center. These oscules in life are subject to at least partial sphinctrate closure, as are also the pores. The pores in spirit-preserved specimens are abundant, 40 μ in diameter, but may have been slightly larger when fully opened in life.

The ectosome of *oceania* is a typical *Spongia* dermis about 15 μ thick, full of heavily pigmented cells. The endosome is the usual dense reticulation. The flagellate chambers

are spherical, about 25 μ in diameter. The abundant fibers consist of nearly opaque, typically rather granular spongin without foreign inclusions. They are 15 to 30 μ in diameter and enclose meshes often about 50 by 200 μ. The scarce ascending fibers are about 60 μ in diameter, and contain a core of fragments of spicules from neighboring sponges.

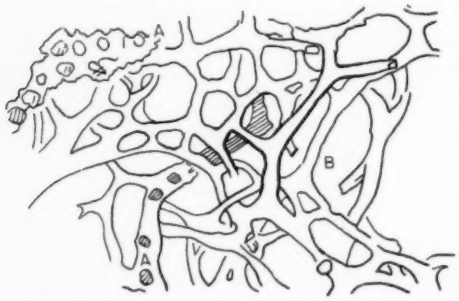

FIG. 4. Fibers of *Spongia oceania* from a camera lucida drawing, × 100. A, principal or ascending fiber; B, common fibers.

No other species of *Spongia* has such numerous oscules of such small average size. A few such small ones may occur here and there in other species but as a rule the oscules are large, often nearly 10 mm. in diameter, and many centimeters apart. Only a few other *Spongia* specimens are as hard as *oceania,* and in each such case it appears decidedly possible that the hardness is due to some local environmental condition. The hardness of *oceania* may be a specific character. It would be interesting, however, to see if soft varieties, imported from elsewhere, would continue to grow soft in Hawaii. The commercial possibilities of *oceania* do not appear great, but they do exist.

The species name is given in respect to the location of this sponge near the center of the world's largest ocean.

The abundance of this species calls for special attention because it is almost, or perhaps could be, a commercial sponge. It is recorded that the ancient Hawaiians collected and used dried specimens, but to only a slight extent. Wet specimens feel somewhat like the usual commercial sponges, and I have used a locally collected sponge in a very practical way in my laboratory. Yet even when wet it is somewhat difficult to compress, and when dry it is almost as stiff as wood. The commercial sponge *Spongia officinalis* variety *dura* from the West Indian region, known in the market as "hardhead," is much like *oceania* in consistency. The best Hawaiian sponges are scarcely third-grade by market criteria, but their ability to absorb and hold water (which may then be readily squeezed out) is quite good. They have a fairly small ratio of gross cavities, so that their chief fault is the unpleasant stiffness.

I first collected this species in Kaneohe Bay (at Moku O Loe) on December 22, 1947, but the specimens from this vicinity were all small, thin encrusting forms, ill suited to reveal the typical characteristics. Mr. Vernon Brock collected the type specimen by "skin diving" and reported that at the type locality the bottom for perhaps as much as several acres was thick with spongias, scarcely a meter apart, and many of them were much larger than human head size. He brought up one specimen over 40 cm. in diameter. It is curious to note that there is probably a greater bulk of this species in the Hawaiian Archipelago than the total bulk of all other shallow-water Hawaiian sponges. Reports came to me of vast windrows of this sponge cast on the beach after storms. On January 24 to 26, 1947, an unusually severe gale struck Hawaii and on January 28, I went almost entirely around the island of Oahu, examining beaches along the south, east (windward), and north shores. I found only a few small fist-size spongias cast up. Almost nothing else was cast up, however, so presumably the wave action of this storm was of some peculiar nature so that it scoured material off the beach rather than depositing it. Extra big deposits of storm-dislodged sponges are

reported from the windward side of the island of Molokai, even masses 2 feet deep extending far along the beach. Reports came to me of large beds of *Spongia* north of the island of Maui and just north of, and also just south of, Kaneohe Bay. Dredging at the latter locality failed, however, to yield a single specimen. During May, 1948, I made a reconnaissance of the large island of Hawaii and found this species rather common along the south and west coasts, but did not similarly explore the turbulent, windward, northeast coast.

Dysidea avara (Schmidt) de Laubenfels

This species is represented to date by only a single specimen collected at Moku O Loe on January 10, 1948. This is now deposited in the U. S. National Museum, Register Number 22749. It was growing on the east side of the dock, near the concrete bridge which connects the dock with the island. It was at a depth of about 2 meters. This is location number 5 on the map.

This specimen is 6 by 7 by 9 cm., massive, and in life it was dull purple outside, brown inside. Its consistency is very spongy, but if dry it would doubtless, like others of the same species, become hard and brittle.

The surface is beset with conules about 2 mm. high and 1 to 8 mm. apart, usually 3 to 4 mm. apart. The oscules are 3 mm. in diameter and 2 to 3 cm. apart. The pores are 50 μ in diameter; about 10 or 14 such occur in each of numerous surface areas. Each such area is about 0.5 mm. in diameter, and represents a mesh in a subdermal reticulation of spongin fiber.

The ectosome consists of a thin dermis much perforated by pores as described. The endosome is fibro-reticulate. The flagellate chambers are 60 μ in diameter, sack-shaped (eurypylous). Both primary or ascending fibers and secondary fibers are loaded with foreign material, but a few fibers in the subdermal reticulation are free from detritus. These latter are 20 to 40 μ in diameter. In the main fibers a few short spaces that are free of inclusions are 100μ in diameter, but the abundant inclusions are often sand grains of 250 μ in diameter.

The species name *avara* was first used as *Spongelia avara* by Schmidt (1862: 29) for a Mediterranean species very much like this one from Hawaii. That *Spongelia* falls in synonymy to the earlier *Dysidea* is made clear by de Laubenfels (1932: 124) if not sooner; earlier authors had speculated that such might be the case. Very similar sponges are recorded from Australia by Lendenfeld (1889: 668) as *Spongelia distans* and are recorded from the Philippines, first by Wilson (1925: 476) as *Spongelia fragilis* and subsequently by de Laubenfels (1935: 327) as *Dysidea pallescens*. Burton (1934: 583) placed many species, including *pallescens*, *distans*, and *avara*, in synonymy with *fragilis*. In a monograph of the keratose sponges (de Laubenfels 1948: 142) I maintain the specific distinctness of *avara* as compared to *fragilis*, including *distans* with *avara*. The species *avara* is never as pale or grayish as *fragilis*, and consistently has a much coarser surface. In addition *fragilis* tends to have larger oscules, often at the distal ends of cylindrical branches. Occasional deformed specimens of *avara* may resemble equally rare deformed specimens of *fragilis*, thus leading to the belief that all are conspecific. *D. avara* appears to be common throughout the Old World, Europe to Australia, and is now recorded in mid-Pacific. *D. fragilis* is world-wide, being found even into the near Arctic.

Pleraplysilla hyalina new species

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22754. It was collected January 10, 1948, in Kaneohe Bay at a depth between 1 and 2 meters, growing on dead coral.

This species formed an extremely thin encrustation, barely 100 μ thick at the thickest unless measured directly at the conules. It spread laterally for distances of several centimeters on the exceedingly irregular surfaces of the coral. It was possible to dislodge postage-stamp-sized pieces with some difficulty. In life the color was blue-gray, and the transparency of the whole sponge was noteworthy. The consistency of the flesh was softly colloidal, scarcely more firm than raw egg white. The fibers were stiffly elastic.

The surface of this sponge was decidedly conulose, with conules 3 to 7 mm. apart and about 2 mm. high. Neither oscules nor pores could be found in the preserved specimen. Doubtless they were almost or quite microscopic in life, and completely contracted in the alcohol or while the encrustation was being scraped off. The whole is so thin that no distinction can be drawn between ectosome and endosome; specifically there was no evident dermis or dermal specialization, merely the surface of the protoplasm.

Doubtless there was a basal plate of spongin. Certainly at intervals spongin fibers rose upward, perpendicular to the base. These fibers are of clear amber-yellow spongin with a central region that is densely packed with spicule fragments and fine sand.

This appears to be the third time that anyone has found this genus, which is separated from the somewhat more common *Aplysilla* by the occurrence of a central region in the fiber filled with foreign detritus. The first was on the north coast of France, as recorded by Topsent (1905: clxxxiv). He described his discovery as *Pleraplysilla minchini.* It differed from the Hawaiian specimen in being opaque and chocolate-brown in color. The second occurrence of the genus was recorded by George and Wilson (1919: 165) at Beaufort, North Carolina. This species, *Pleraplysilla latens,* was described as colorless, conules less than 1 mm. high; the distance between conules was not given. In 1946, I spent the summer at Beaufort, but was unable to find a trace of *Pleraplysilla.* Of course it is an exceptionally inconspicuous sponge. The Hawaiian species is set off by color from *minchini* and in color and conule size from *latens.* The specific name selected refers to its transparency.

Hexadella pleochromata new species

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22748. It was collected January 10, 1948, in Kaneohe Bay at a depth of between 1 and 2 meters, growing on dead coral. It was also collected by dredging at 50 meters depth on the opposite side of Oahu, in the ocean south of Pearl Harbor, on February 19, 1948.

This species forms a thin encrustation not quite 1 mm. thick. In life the color is sulfur-yellow, but upon dying it turns purple. The consistency is fleshy, modified by the tough dermis.

The surface of this sponge was smooth, with scattered openings 25 to 60 μ in diameter. No distinction between exhalant and inhalant openings could be made.

The ectosome is a tough organic cuticle, giving no evidence of cellular nature but instead is almost certainly suitably called spongin. The endosome is completely askeletal, comprising only the protoplasmic sponge structures. The flagellate chambers are large, sack-shaped (eurypylous), 30 by 60 μ in size.

Hexadella was established by Topsent (1896: 119), like the preceding genus, for thin encrustations found on the north coast of France. He used two species names, *racovitzai* (the type) and *pruvoti.* Both were yellow, the only difference being that the former had rose-red tints. The two have long been regarded as conspecific but to clarify the literature, such reduction to synonymy is definitely made here. It is noteworthy that *racovitzai* does not turn purple on dying. The critical diagnosis of *Hexadella* concerns the

lack of mineral or fibrous skeleton but the presence of a tough spongin dermis.

Dendy (1905: 61) established *Hexadella indica* from India. This was red when alive, lamellate and folded, with peculiar surface openings called "chones." Burton (1926: 2) described *Hexadella kirkpatricki* from South Africa. This was gray, with papillate oscules, and erect habitus. Burton (1937: 43) described *Hexadella purpurea* from India. This was purple in life, not at all folded like *indica*, and the endosome contained much foreign detritus.

Hexadella pleochromata is sharply set off from the other species in the genus by its change of color from yellow to purple upon dying. On the other hand, exactly such a change is exhibited by one species of *Aplysilla*, one or two species of *Ianthella*, one undescribed species of *Thorectopsamma*, one undescribed species of *Hippiospongia*, and several species in *Verongia*. Thus it is a trait that is widespread in the families of the order Keratosa. It is clearly based on the occurrence of a pigment that has the properties of an indicator. It may be regarded as practically certain that in a sufficiently acid medium this pigment is yellow, whereas in a sufficiently alkaline medium it is dark purple. The chemistry involved is being worked out at Yale University for the related pigments in *Aplysilla* and *Ianthella*.

XYTOPSIPHUM new genus

This genus is erected in the family Desmacidonidae with the following species, *Xytopsiphum kaneohe*, as genotype. It should be emphasized that this is a genus with strongyles as megascleres and arcuate chelas for microscleres. In the type, the latter are peculiar, with greatly reduced clads.

The genus *Xytopsihis* de Laubenfels (1936: 54) has a description essentially like this one, and there are some sound reasons for arguing that the species *kaneohe* should be put in it. On the other hand, the type of *Xytopsihis* was emphasized as being the sponge which Bowerbank (1875: 287) described as *Halichondria aspera*, from a specimen from the Malayan region. This might be considered fairly close to the Hawaiian faunal region, too. Were Bowerbank's description accurate, the matter would be simple. On May 26, 1948, however, Dr. Maurice Burton of the British Museum (Natural History) wrote me a personal letter stating that the type specimen of *aspera* was in his museum, a dried specimen, and that it is not at all as Bowerbank described it; instead it is a *Tedania*.

One might argue that because *aspera* does not fit the diagnosis of *Xytopsihis* it cannot go into that genus, is not and cannot be the type thereof, hence, that the following new species which does fit the diagnosis must become the type of *Xytopsihis*. Against this I will set the following considerations. The original generic designation said "*Xytopsihis* is established for genotype *Halichondria aspera* Bowerbank"; furthermore, the description mentioned chelas of two sizes, so that the Hawaiian sponge does not fit perfectly. It is here considered that *Xytopsihis* falls with *aspera*, into synonymy to *Tedania*.

Xytopsiphum is not secure in its allocation to the Desmacidonidae. This family contains many genera that may be discovered, if adequate data about surface structure become available, to resemble more the Adociidae, or perhaps a new family between the older two. *Xytopsiphum* may go into this still hypothetical new family. Its closest relatives are now in the Desmacidonidae; these are *Plumocolumella* (megascleres oxeas, microscleres perhaps really like those of *kaneohe*, but the surface structure hispid) and closer still, *Xytopsaga*, whose megascleres are hastate tornotes, and whose microscleres are arcuate chelas. They are rather commonplace chelas whereas those of *kaneohe* are peculiar, with minute clads, as in *Plumocolumella*. On the island of Hawaii there occurs an un-

described species of sponge which I regard as congeneric with *kaneohe*; it is definitely closely related. Yet this undescribed sponge has somewhat commonplace arcuate chelas as its chief point of separation from *kaneohe*, and therefore it approaches the genus *Xytopsaga*. On the other hand, *Xytopsaga* has much coarser structure and seems to be confined to the Antarctic region.

The generic name is based upon a modification of the older name *Xytopsibis*.

Xytopsiphum kaneohe new species
Fig. 5

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22742. It was collected January 10, 1948, at Moku O Loe, in the shadow of the walk along the south side of the series of small artificial lagoons, east of the dock, depth about 1 meter, location number 4 on the map. Another specimen was collected on September 27, 1947, in Waialua Bay, Oahu, at a depth of about 6 meters, on dead coral.

Both specimens were thin encrustations 1 to 5 mm. thick, covering areas of between 10 and 20 square cm. The type was very dark, almost black, but the color promptly dissolved out (and disappeared) in alcohol, leaving a pale grayish-pink specimen. Many sponges have a melanotic pigment, but it is quite resistant to alcohol. It may be that the dark hue of this specimen was due to some foreign material on the surface. The other specimen was reddish-brown, mottled. In alcohol it has become the same dull color as the type. The consistency is soft.

The surface of this species is relatively smooth, and the pores are not evident, probably due to rapid closing. On the Waialua specimen there is a surface hole, 0.5 mm. in diameter, with slightly raised rim, that may or may not be an oscule. Otherwise (and chiefly) the species is lipostomous, as are many thin encrusting sponges.

The ectosome is semidetachable, rendering family allocation of the genus difficult. There are many spicules tangentially placed in the dermis, but these are the same as the megascleres of the interior. The endosome is dense, with spicule tracts that range up to 50μ in diameter, 150 spicules per cross section, spongin dubiously present.

FIG. 5. *Xytopsiphum kaneohe*, spicules, from a camera lucida drawing, × 400. A, strongyles; B, sigmoid microscleres, probably reduced arcuate isochelas.

The megascleres are straight strongyles, 3 to 4 μ thick, 200 to 210 μ long. In one place in the Waialua specimen there are deformed but otherwise commonplace arcuate chelas; their absence from the rest of the specimen would indicate that they are foreign. In both specimens there are very abundant peculiar microscleres that are to be regarded as arcuate chelas, but the clads are so small that one obtains a first impression that these are sigmas. On the other hand, they are not at all contorted, as most sigmas are, but lie in one plane. These distinctive microscleres have a chord length of 15 μ in the Waialua specimen, but of only 10 μ in the type specimen.

The species name given refers to the type locality.

Callyspongia diffusa (Ridley) Burton
Fig. 6

This species was first studied in Hawaii on September 10, 1947, at the dock at Moku O Loe (location 6, Fig. 2). This specimen is deposited in the U. S. National Museum Register Number 22741. The species was found again on September 27, 1947, at Waialua Bay, and thereafter several times in various places in Kaneohe Bay, where it is

moderately common. The shape is typically ramose, but juvenile specimens are temporarily encrusting. The branches are about 6 mm. in diameter, and often more than 12 cm. high. Three to five branches occur in the average mass. The color, in life, is dull drab with more or less lavender tinges; the more the sponge was exposed to light, the more lavender it shows. The consistency is very spongy.

The surface is superficially smooth. The pores in the protoplasmic dermis are often 40 μ in diameter. The oscules are 4 to 6 mm. in diameter, with raised rims often 3 mm. high.

The surface is covered by a network of fibers which are smaller than the fibers of the endosome and form smaller meshes. This is quite typical of *Callyspongia.* There is some ground for regarding the Hawaiian specimens as representing a new species, because unlike any other *Callyspongia* there is no coarser dermal net to include the finer one in its meshes; this is offset by the fact that there is such a net just below the surface. The endosome is a typical callyspongoid fibroreticulation.

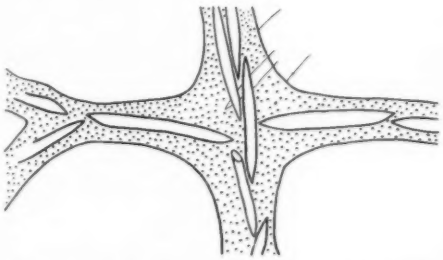

FIG. 6. *Callyspongia diffusa,* bit of the endoskeleton, × 320, showing spicules (oxeas) in spongin fibers. From a camera lucida drawing.

The dermal fibers are 10 to 15 μ in diameter, contain a single row of spicules, and form meshes that are 60 to 100 μ in diameter, usually about 75 μ. The protoplasmic dermis is in this same plane. The endosomal fibers are 25 to 35 μ in diameter in the Kaneohe specimen, about 40 μ in diameter in the one from Waialua Bay. In the latter there are several rows of spicules in some ascending fibers; in the Kaneohe specimen all the fibers have only the uniserial core of spicules. The endosomal meshes are 50 to 500 μ, often about 200 μ, in diameter, more or less rectangular. The spicules are oxeas, rather hastate; typical sizes are 4 by 100, 5 by 90, 6 by 75 μ. In one specimen I found one toxa 25 μ long. This is probably accidental, but is thought provoking in view of the similar color and shape of *Toxadocia* (p. 16) which has many toxas. *Toxadocia,* however, has a different sort of ectosome from *Callyspongia.*

Many species of *Callyspongia* are tubular in shape, with thin walls around the central hollow, which has a large distal opening. The type of the genus, *C. fallax,* is solid cylindrical, however. The species *diffusa* is perhaps best characterized by its relatively thick spicules. It was first described as *Cladochalina diffusa* by Ridley (1884: 183) from the Indian Ocean. It was subsequently recorded as *Cladochalina elegans* by Lendenfeld (1887: 770) from South Australia, as *Chalina pulvinatus* by Lindgren (1897: 481) from the Malay region, as *Ceraochalina retiarmata* by Dendy (1905: 152) from India. It is discussed, with synonymy, by Burton (1934: 541).

DAMIRIANA new genus

This genus is erected in the family Phorbasidae with the following species, *Damiriana hawaiiana,* as genotype. It should be emphasized that this is a genus with a special dermal skeleton of tylotes over an endosomal skeleton of oxeas, with arcuate chelas among the microscleres.

Within this family the genus *Damirielia* seems fairly close to *Damiriana*; all the other genera are widely different. None of the others has dermal tylotes, although such spiculation is common in the family Myxillidae.

All the others, with the dubious exception of *Iophonota*, do have echinating spicules. *Damiriella* has principal spicules that are strongyles whereas *Damiriana* has oxeas, otherwise the two are close. *Damiriella* is a rare genus, with only one species, itself rather rare, reported only from the Mediterranean coast of France.

The name *Damiriana* is selected to show plainly the resemblance to *Damiriella*.

Damiriana hawaiiana new species

Fig. 7

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22737. It was collected September 10, 1947, at Moku O Loe, in shallow water near the pier. It has been common at location 3 (Fig. 2), just inshore of the bridge over the long lagoon. It seems to grow very slowly. Several times during 1947 and 1948 bits were removed for study, and by just that much the total quantity present seems to be semipermanently reduced. In the fall of 1948 what might be a total of one or two handfuls remained.

In August, 1945, R. W. Hiatt carried out an extensive ecological survey on the south shore of the island of Hawaii, at a nearly inaccessible and therefore relatively natural and undisturbed region called Halape. He found at least one specimen of *Damiriana* growing on coral in a very exposed situation, quite in contrast to the quiet lagoon in Kaneohe Bay.

On May 19, 1948, at Kailua on the north Kona coast (west side) of the island of Hawaii I found a small, somewhat aberrant specimen of this species growing just barely below low tide.

Damiriana hawaiiana comprises first an amorphous basal region, often about the size of a hen's egg. From this, one or a few branches arise, little-finger size and shape. The color is a brilliant vermilion-red, and the consistency is soft, easily torn. The Kailua specimen was dull orange rather than flame-colored.

The surface is superficially smooth. The oscules may be terminal or lateral, may number six or more per specimen, and open as wide as 6 mm. They are conspicuously closable by a membrane which is pulled inward from all sides, maintaining the circular outline of the shrinking aperture. At least 5 minutes are required for complete oscular closure. The surface is perforate with gross pores, which in some places almost touch each other, elsewhere are far apart. Each of these, about 1 mm. in diameter, is in turn filled with a finer network, the meshes of which are barely 150 μ in diameter, 20 to 30 such openings per sieve. In places there are scattered pores, not so grouped, each about 40 μ in diameter.

The ectosome is a definite dermis, less than 100 μ thick, with its special spicules tangentially placed. The endosome is somewhat like "crumb of bread," with its special spicules chiefly in confusion, or in vague tracts about 100 μ in diameter. They often are placed so as to outline chambers, as in the genus *Myxilla*. The flagellate chambers are spherical, 25 to 40 μ in diameter. There is abundant colloidal material present.

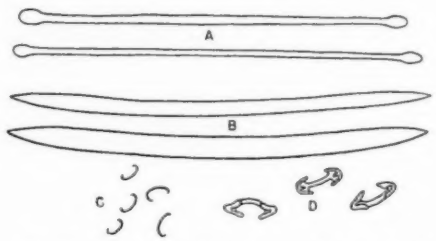

FIG. 7. *Damiriana hawaiiana*, spicules, from a camera lucida drawing, × 333. A, dermal tylotes. B, endosomal oxeas. C, sigmas. D, arcuate isochelas.

The ectosomal megascleres are tylotes, usually about 5 by 200 μ, although in one specimen, otherwise typical, they were only 4 by 170 μ. This is a minor difference. The endosomal megascleres are oxeas, usually about

8 by 200 μ, but sometimes 9 by 230. A few thicker, shorter ones, 12 by 180 μ, may be found, for example. The microscleres are of two sorts. There are abundant, commonplace, arcuate isochelas, 27 μ long. In the aberrant Kailua specimen there were also some only 15 μ long. A second category of microscleres appears to be a sort of sigma. It is C-shaped rather than S-shaped, is in one plane, not contorted. This suggests that it might be a reduced chela, and accordingly a search was made with immersion microscopy for traces of clads. At least one inward pointing clad is certainly present, perhaps three. The difficulty of being sure is due to the size of this spicule. Its chord length is 13 μ, its diameter 1 μ, the clad or clads are less than 1 μ in length, and at the widest about a third or a fourth of a micron in diameter, tapering to a point.

The species name is given in honor of Hawaii.

NEOADOCIA new genus

This genus is here erected in the family Adociidae, with the following species, *Neoadocia mokuoloea,* as genotype. It should be emphasized that this is a genus with an ectosomal skeleton of tangentially placed oxeas overlying an endosomal skeleton of oxeas, with raphides as microscleres. This is like *Adocia* except for the addition of raphides; it is set off from all other genera in the family by the possession of these microscleres.

The generic name is selected to show the close relationship to the genus *Adocia.*

Neoadocia mokuoloea new species

Fig. 8

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22745. It was collected September 10, 1947, at a depth of about 2 meters, near the dock at Moku O Loe (location 6, Fig. 2). Only the single specimen was found. I have repeatedly searched for others but without success.

The specimen is a mass 2 by 3 by 3 cm. Two holes go right through it, perhaps caused by foreign objects about which it grew; one of these is 3 mm. and the other is 9 mm. in diameter. The color in life was golden-yellow for all the interior and much of the exterior, but externally there were rosy-red patches. The consistency is very soft.

The surface is exceptionally punctiform. It is liberally perforated by apertures 1 mm. in diameter, more than 20 per square cm. of surface, on all surfaces except the surface of attachment. It is not clear which of these apertures are inhalant and which exhalant, unless it may be that all are pores, and the two large openings mentioned above may be the oscules. It would be interesting to have additional specimens and so be able to ascertain more of the structure of this species.

FIG. 8. *Neoadocia mokuoloea,* spicules, from a camera lucida drawing, × 444. A, megasclere (oxea). B, microscleres (microxeas), or raphides.

The ectosome contains a tangent dermal skeleton of smooth diacts, over subdermal spaces. The endosome is cavernous, with an isodictyal reticulation of smooth diacts and few or no spicule tracts at all. The megascleres are all smooth oxeas, 6 by 120 to 6 by 135 μ. The microscleres are commonplace raphides, about 0.5 μ thick, but upwards of 100 μ long.

Adocia baeri occurs in the Philippine Islands. It was first described as *Reniera implexa* variety *baeri* by Wilson (1925: 398) and made a species by de Laubenfels (1936: 328). This *Adocia* is very different from *mokuoloea* in appearance, being nearly black. It contains a few very thin spicules, but these

may merely have been juvenile forms of the megascleres, inasmuch as they are uncommon. There seems to be no way to discriminate between such immature forms and clear-cut raphides, unless the latter are so numerous that it is unlikely that they are juveniles. If it should happen, as I believe unlikely, that *baeri* has genuine raphides, then it should be transferred from *Adocia* to *Neoadocia.* This transfer is not here made.

The name of this new species is derived from its type locality, the island of Moku O Loe.

Toxadocia violacea new species

Fig. 9

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22752. It was collected November 3, 1947, at Moku O Loe, at a depth of 1 meter, in the long pool near location number 3 in Figure 2. This species was also found growing in numerous places on dead coral throughout Kaneohe Bay, but not on the leeward side of Oahu. On the island of Hawaii I found it in at least two places near Hilo, which is on the windward side of that island.

This species is basically encrusting, but the numerous oscules are raised on little hillocks about 1 cm. high. Some projections are so long (15 mm.) but so narrow (3 mm.) as to resemble fistules. Few colonies reach the size of the palm of the hand or a basic thickness of as much as 1 cm. The color is a vivid violet and the consistency is soft and fragile.

The surface of *Toxadocia violacea* is smooth, provided with a translucent dermis over extensive subdermal cavities. The pores in this dermis are abundant, contractile, about 30 μ in diameter. The openings that lead down from the floor of the subdermal cavity are rather more conspicuous than those in the dermis, being readily visible through it. They are less numerous and are about 150 μ in diameter. The oscules are about 3 mm. in diameter, and are often raised 8 to 16 mm. above the surface on rounded projections.

The dermal membrane is full of spicules tangentially arranged, but in little more than one single layer. The endosome is microcavernous, permeated by an isodictyal reticulation of spicules.

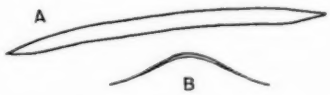

FIG. 9. *Toxadocia violacea,* spicules, from a camera lucida drawing, × 444. A, oxea. B, toxa.

All the megascleres are smooth oxeas, about 4 by 120 μ. A few are larger, especially in the specimens from Hilo, where a size of 7 by 140 μ is sometimes reached. The microscleres are toxas, 1 by 60 μ. Some thin, straight spicules may be raphides, or juvenile megascleres, or merely edgewise views of toxas; they are not regarded as worthy of emphasis.

There are seven other species which have been assigned to the genus *Toxadocia.* Two, *toxius* and *toxophorus,* are East Indian, and one might expect them to be the most like this Hawaiian species, but such is not the case. Each has, for example, a very peculiar type of toxa which differs from those of all others in the genus. Two species from the tropical Atlantic, *abbreviatus* and *tener,* have megascleres that are many times larger than those of the Pacific species. One from Great Britain, *fallax,* has large spicules, but not nearly so large as those from farther south. There are two Arctic species, *primitivus* and *proximus,* and these have still smaller megascleres, and approach closest of all to the Hawaiian *Toxadocia.* Their toxas are much larger, however, and they and all other hitherto described members of this genus are recorded as yellow in color. Emphasis is laid here on the spicule differences and, particularly, on the color. The species name

violacea is derived from the violet hue of this sponge.

Myxilla rosacea (Lieberkühn) Schmidt
Fig. 10

This species is represented in the fauna of Hawaii by only two known specimens; both were collected at Moku O Loe in Kaneohe Bay. The first specimen was taken September 10, 1947, at a depth of 1 or 2 meters, on pilings at the dock (location 6, Fig. 2). This is deposited in the U. S. National Museum, Register Number 22734. A second was found January 10, 1948, in the sluice-way from one of the small lagoons (location 4, Fig. 2).

This sponge is massive. Our specimens are each fist-size, but much of the bulk is due to contained lumps of dead coral. The color in life is bright orange-red, paler in the interior. The consistency is slightly spongy, not especially remarkable. The surface is slightly and irregularly lumpy. There is a conspicuous translucent dermis pierced by microscopic contractile pores; through it the larger canals that lead into the sponge from the floor of the subdermal space are easily seen. These openings are about 0.3 mm. in diameter and 1.2 mm. apart. The oscules are few and scattered, about 6 mm. in diameter, and closable by very thin membranes.

The ectosome is packed with special dermal spicules arranged tangentially. The endosome is cavernous, "crumb of bread" type, with the skeleton in "log cabin" or modified isodictyal arrangement about small gross chambers.

The ectosomal spicules are smooth-shafted tornotes; their ends are just faintly microspined, their size about 3 by 160 μ. The endosomal spicules are acanthostyles, 8 by 140 μ. The microscleres include anchorate isochelas, approaching the unguiferate type but only 15 μ in total length, and also commonplace sigmas, 18 to 30 μ in chord length.

This species was first described from Europe, as *Halichondria rosacea,* by Lieberkühn (1859: 521). It was transferred to *Myxilla* (genotype) by Schmidt (1862: 71). It is abundant throughout Europe, on both the Mediterranean and Atlantic coasts, but appears to be absent from the Americas.

The European specimens and these from Hawaii agree rather closely. The former have isochelas that are often nearly twice as large as those of the latter, but this is scarcely a specific difference in view of the other similarities.

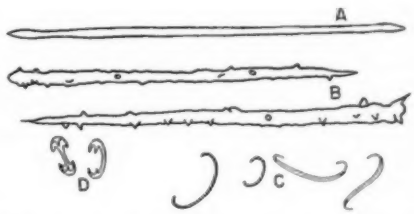

FIG. 10. *Myxilla rosacea,* spicules, from a camera lucida drawing, × 444. A, dermal tornotes. B, endosomal acanthostyles. C, sigmas. D, anchorate isochelas.

In reviewing the very numerous species of the genus *Myxilla* with a view to identifying the Hawaiian specimen, various items become noteworthy. The genus *Burtonanchora* de Laubenfels (1936: 94) was established for certain species formerly in *Myxilla* but differing chiefly in that they have only smooth spicules, and thus passing over into the family Tedaniidae. Perplexing intermediate forms, having spicules that are only very slightly spined, exist; yet for convenience, if nothing else, the division is worth maintaining. The following additional species are now taken out of *Myxilla* to go into *Burtonanchora: M. acribria* de Laubenfels, *M. cribrigera* Ridley and Dendy, *M. mollis* Ridley and Dendy, and *M. novaezealandiae* Dendy. Two species, *D. inaequalis* and *D. simplex,* first put in *Dendoryx* by Baer, are also placed in *Burtonanchora.*

Four others appear to require transfer from *Myxilla* into the related genus *Lissodendoryx*. They are *M. behringensis* Lambe, *M. cratera* Row, *M. firma* Lambe, and *M. pygmaea* Burton.

Topsent (1893: xxiv) described a sponge from the Mediterranean coast of France as *Myxilla arcitenens*. The megascleres and chelas are like *Myxilla*, but unlike this genus there are not (as usual) sigmas, and there are (as never in *Myxilla*) raphides and toxas. This is clearly not *Myxilla*. If there were no chelas it would fit *Achiliderma*. Because there is no genus now set up for this sponge, a new one is required, and is established as:

QUINTOXILLA new genus

This genus is assigned to the family Myxillidae, genotype *Myxilla arcitenens* Topsent. The holotype location is unknown to me; Professor Topsent told me personally that he rarely kept or deposited specimens. This is a genus with smooth dermal diactinal or sometimes inequiended spicules, and a principal skeleton of acanthostyles. The microscleres are isoschelas (presumably, but not certainly, anchorate) and toxas. Raphides may be among the microscleres, but this is not emphasized here. The name is arbitrary, not descriptive, suggested however by the emphasis upon the toxas of the spiculation.

NANIUPI new genus

This genus is erected in the family Myxillidae, subfamily Grayellinae, with the new species *Naniupi ula* as genotype. It should be emphasized that this is a genus with ectosomal acanthoxeas, endosomal smooth styles, and echinating acanthostyles. The microscleres include arcuate chelas. The genotype also has peculiar sigmoid microscleres. The genus name is derived from the native Hawaiian language, "nani" meaning beautiful and "upi" meaning sponge.

The subfamily Grayellinae is characterized by spiny diacts over smooth monacts. The type genus, *Grayella*, has similar ectosomal acanthoxeas to those of *Naniupi*, as very few sponges do, but the endosomal spicules of *Grayella* are smooth tylostyles with no echinating spicules or microscleres. Brøndsted (1932: 14) described a sponge from east of Iceland as *Grayella akraleitae*. This has a spiculation of lumpy styles echinated by acanthostyles, with arcuate chelas as microscleres. This cannot be a *Grayella*, but belongs in the family Microcionidae in which, however, a new genus is required for its reception, and is here established as:

RAMOSICHELA new genus

This genus is assigned to the family Microcionidae, genotype *Grayella akraleitae* Brøndsted. The location of the holotype is not known to me. This is a genus for sponges with a principal spiculation of styles not smooth, in tracts that are echinated by acanthostyles; there are also arcuate isochelas. Within this family all the other genera have one or more categories of smooth megascleres except the genus *Ramoses*, which has no microscleres but is otherwise much like *Ramosichela*. *Ramoses* is exclusively Antarctic and sub-Antarctic whereas *Ramosichela* is Arctic or sub-Arctic. The genus name is derived from that of this related genus, *Ramoses*.

To continue with an analysis of the subfamily Grayellinae, de Laubenfels (1936: 88) puts *Crellomyxilla* here, but upon further consideration it is thought preferable to transfer this genus to the family Microcionidae, subfamily Yvesiinae. *Tethyspira* has been put in the Grayellinae with some doubt, and is, still doubtfully, left there. It has small acanthostrongyles that may be regarded as dermal; its main spicules are large smooth styles. A fourth genus belongs in this subfamily, on the basis of published descriptions, but as it too is unnamed it is here named as follows:

QUINDESMIA new genus

This genus is assigned to the family Myxillidae, subfamily Grayellinae, genotype *Hymedesmia inflata* Bowerbank (1874: 245, pl. 79). The holotype is probably in the British Museum of Natural History. This is a genus for sponges with special ectosomal acanthoxeas and endosomal smooth monaxons echinated by acanthostyles, but without microscleres. It is reported only from Great Britain and is evidently quite rare. The name is arbitrary rather than descriptive.

Thus it appears that there are now four genera in the Grayellinae, of which *Naniupi* is the only one to have microscleres.

Naniupi ula new species

Fig. 11

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22740. It was collected January 10, 1948, in Kaneohe Bay, at a depth of about 2 meters, growing on dead coral. On February 19, 1948, a similar specimen was dredged from a depth of about 50 meters, in the open ocean about 3 kilometers south of Pearl Harbor, on the opposite side of Oahu from Kaneohe Bay.

This rather uncommon sponge is a paper-thin encrustation, spreading indefinitely laterally. The type specimen came from a colony that covered an area about as large as a human hand, of very irregular outline due to the deeply sculptured mass of dead coral on which it grew. The color in life is a distinctive vivid carmine-red. The consistency is obscured by the extremely thin habitus.

The surface of *Naniupi ula* is smooth and lipostomous. The ectosome is a well-marked dermis, packed with a felted mass of tangentially arranged acanthoxeas. The endosome is dense, with its spicules in some confusion.

The special dermal acanthoxeas are about 4 by 110 μ. The endosomal megascleres are chiefly smooth styles about 4 by 190 μ. A few of these are pseudoxeas. In the deepest portions are a few echinate spicules, acanthostyles 7 by 130 μ. The principal or only microscleres are abundant, rather typical arcuate isochelas, 21 μ in total length. At least in the type specimen a few other spicules occur that seem, at first glimpse, to be microscleres. They are only about 1.5 μ thick, 80 μ long, very faintly microspined, and four times curved like two S-shaped sigmas end to end. There are, however, other similar spicules that are nearly straight, and these

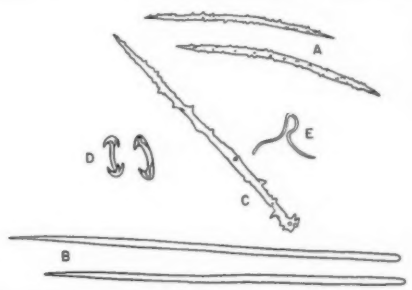

FIG. 11. *Naniupi ula*, spicules, from a camera lucida drawing, × 333. A, dermal acanthoxeas. B, endosomal styles. C, echinating acanthostyle. D, arcuate isochelas. E, peculiar contort microsclere.

latter give evidence of being juvenile forms of the dermal acanthoxeas. The much curved spicules may be malformed examples of the same juvenile sort, but their occurrence is noteworthy. As additional specimens are found, this type of spicule should be looked for. I do not find them in the specimen collected south of Oahu.

The species name is derived from the native Hawaiian word for red, because of the brilliant color of this species.

HIATTROCHOTA new genus

This genus is erected in the family Tedaniidae with the following species, *Hiattrochota protea*, as genotype. It should be emphasized that this is a genus with smooth strongyles as special ectosomal spicules, smooth styles as endosomal megascleres, and birotulates or amphidiscs among the microscleres, without chelas.

The genus *Iotrochota* may be regarded as a sort of nomenclatorial parent for all the marine Demospongiae having amphidiscs. Such spicules are common in the fresh water sponges (subfamily Meyeniinae) and in the order Amphidiscophora of the Hyalospongiae. As more and more species were put in *Iotrochota* for this reason, it became evident from their other characteristics that they actually belonged to several families. The type of *Iotrochota (birotulata)* is in the Desmacidonidae. In 1936 de Laubenfels took out many species, establishing from them the genera *Hymetrochota* and *Iotroata* in the Myxillidae, and *Iotaota* in the Tedaniidae. *Hiattrochota* is also in this latter family. The two myxillids have megascleres typical of that family; *Hymetrochota* has only amphidiscs for microscleres, *Iotroata* also has unguiferate chelas. Of the tedaniids, *Iotaota* matches the latter, with both amphidiscs and unguiferate chelas as well as megascleres typical of the family. *Hiattrochota* matches *Hymetrochota,* with only amphidiscs as microscleres, but megascleres typical of Tedaniidae.

The terminus of the new generic name follows the pattern as used for the comparable genera, but the distinctive prefix is given in honor of the eminent zoologist, Robert W. Hiatt.

Hiattrochota protea new species

Fig. 12

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22750. It was collected December 22, 1947, at Moku O Loe, at a depth of about 1 meter, in a sluiceway (location number 4, Fig. 2). Another specimen was collected May 16, 1948, at Kaalualu, near the south end of the island of Hawaii. Yet a third slightly different specimen was collected May 17, 1948, at Honaunau on the Kona coast of the island of Hawaii.

This species is massive, about fist-size, and in life is velvety black. The spirits in which it is preserved are stained dark brown, but the sponge retains its hue. The consistency is somewhat elastic, not remarkable.

The surface is rather smooth, most of the pores having quickly contracted. A few openings about 1 mm. in diameter are dubiously regarded as unclosed pores. The oscules are 1 to 3 mm. in diameter and characteristically each is situated at the summit of a rounded dome or lobe, more than 1 cm. in diameter, but only about half as high.

The ectosome consists of a definite dermis over subdermal spaces, but is much less flesh-

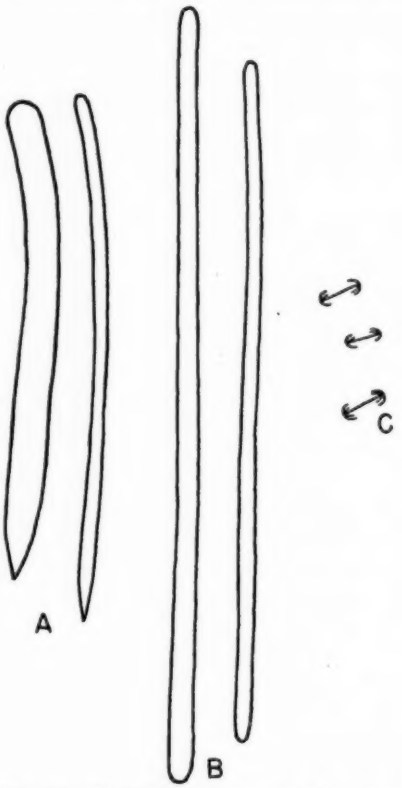

FIG. 12. *Hiattrochota protea,* spicules, from a camera lucida drawing, × 666. A, endosomal styles. B, ectosomal strongyles. C, amphidisc or birotulate microscleres.

like than that of *Iotrochota.* The endosome is microcavernous with a skeleton that approaches the isodictyal condition, very much as in *Tedania.* There are a few vague spicular tracts, about 50 μ in diameter in the type specimen but somewhat more than twice as thick in the second specimen. The latter grew on the beach of the open ocean, whereas the type was in calm water; this probably accounts for the difference.

The ectosomal spicules are smooth strongyles 3 by 140 to 6 by 205 μ in size. The endosomal spicules are smooth styles 7 by 135 to 10 by 180 μ in size. Both sorts are consistently a little larger in the Kaalualu specimen. Both sorts are somewhat thicker, up to 12 μ, in the Honaunau specimen. The microscleres are amphidiscs. Their length is 12 to 13 μ in the type specimen, 15 μ in both others. There are often only four clads at each end in those of the type specimen, usually more clads in the corresponding spicules of the other two specimens. In the type specimen the clads are less strongly recurved. In the Honaunau specimen, as in many hyalospongoid amphidiscs, the shaft is visibly spiny.

The species name is given because this is the first of the genus.

Tedania ignis (Duchassaing and Michelotti) Verrill

Fig. 13

This species is very common throughout the shallow waters of Hawaii including Kaneohe Bay. It is represented by a specimen collected at Moku O Loe from coral, near the pier (location number 6, Fig. 2). This specimen is deposited in the U. S. National Museum, Register Number 22744.

This species is basically encrusting, with the oscules often so elevated that chimneys as tall as 4 to 7 cm. result, yet these chimneys are usually less than 1 cm. in diameter, hollow, and thin-walled. Specimens are sometimes as large as a hand, more often somewhat smaller. The color is bright vermilion where the sponge tissue grew in brilliant illumination, but more orange, even to yellow, in proportion to the amount of shade in which the sponge grew. The consistency is soft and the sponge easily torn or compressed.

The surface is smooth, with abundant, very contractile pores. The oscules are from 2 to 7 mm. in diameter, often raised in the form of tubes. The ectosome is a definite dermis, over subdermal spaces, and is packed with special spicules, not always horizontal but instead in many orientations; some clusters are actually perpendicular to the surface. The endosome is finely cavernous, somewhat "crumb of bread" style, with its spicules in quite confused arrangement.

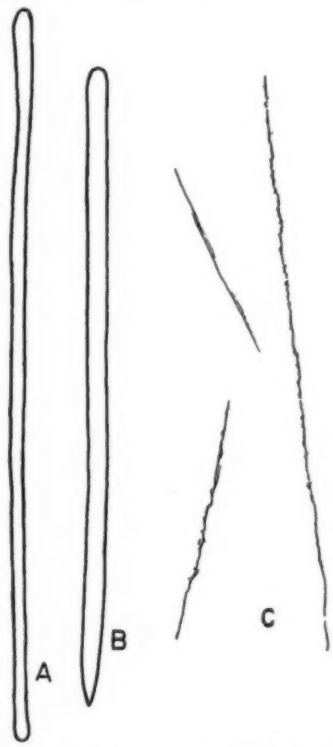

FIG. 13. *Tedania ignis* (?), spicules, from a camera lucida drawing, × 666. A, dermal tornote. B, endosomal style. C, microspined raphides.

The special dermal spicules are usually regarded as tylotes, but the ends are so minutely enlarged that the spicule at first seems to be a strongyle and often really is a strongyle. It is rather that there is a very slight constriction near the end of each spicule than that the end is actually swollen. On each extreme tip of these spicules there are a number of very fine spines. These spicules nearly all range in size between 3 by 180 and 4 by 210 μ. The principal spicules are smooth styles, often curved a little, and range from 6 by 160 to 8 by 210 μ. The abundant microscleres are peculiar microspined raphides, usually less than 1 μ in diameter, but occasionally as thick as 2 μ with total lengths up to at least 200 μ.

Within the genus *Tedania* there are some 45 names, besides others that have been transferred to other genera. Some of the 45 are clearly synonyms, but others arouse serious questioning. There are some well-marked differences. One group of three or four species has two distinct categories of microscleres. On the west coast of North America two species (or is it all one?) have tylostyles instead of styles for principal spicules. Some deep-water species have enormous spicules and distinctive, symmetrical habitus. There remain about 20 species that differ in color and in having spicules a little larger or smaller. Burton (1932: 344) and also Burton and Rao (1932: 353 and following) argue that all these are conspecific and call them all *Tedania nigrescens,* which then would become an amazingly cosmopolitan species. Perhaps some further analysis is in order, and, in particular, color may be quite significant.

The genus *Tedania* was established by Gray (1867: 52) for *Reniera digitata* Schmidt (1862: 75) and *Reniera ambigua* Schmidt (1864: 39). The former was shown to be a synonym of *Reniera nigrescens* Schmidt (1862: 74) and the type is assumed by Burton and others to be called *nigrescens.* This designation was made official by de Laubenfels (1936: 89). Topsent (1939: 5) pointed out, however, that *digitata* and *nigrescens* both fall to the earlier *Halichondria anhelans* Lieberkühn (1859: 522). This species, under various names, is well known from the Mediterranean, where it seems to be the only *Tedania.* It is regularly and consistently described by the various authors as being black or nearly so; some say very dark blue, some say very dark green. I have not found these colors in the field or in the literature from other parts of the world. It may be that the Mediterranean form is well characterized by color. Burton and Rao have implied, but without actual data, that it has similar spiculation to West Indian *Tedania.* On the other hand, published descriptions show that the Mediterranean *Tedania* has the endosomal styles two to seven times as thick as the ectosomal tornotes. I find, in very numerous specimens, no such difference in West Indian *Tedania,* in which the thickness varies from the same to one and one-half times that of the tornotes.

The West Indian form, which I am convinced is specifically distinct from *anhelans,* was first named *Thalysias ignis* by Duchassaing and Michelotti (1864: 83) and transferred to *Tedania* by Verrill (1907: 339). It is regularly brilliant red, almost spectral red, but tending a little toward vermilion. I have examined thousands of specimens, and found extreme uniformity.

Numerous species names for *Tedania* have been established for forms occurring in the East Indian region. These all have spicules thicker than those of *ignis;* they vary from slightly longer to one and one-half times as long. The colors are usually cited as yellow, in a few cases tending toward red.

The allocation of the Hawaiian *Tedania* must be regarded as provisional; I do not feel that its position can be settled at present. If the attitude of Burton and Rao is adopted, it is *Tedania anhelans,* and so are a score of

other forms. In color it is like the East Indian species, unlike typical *Tedania ignis*; but in spiculation it is indistinguishable from *ignis*.

Tedania ignis gives a pronounced irritation to most people who touch it (those with very calloused hands are safe). This irritation includes a reddening of the skin, swelling, extreme tenderness to the touch, and lasts 3 to 7 days. I obtained such an irritation from the Hawaiian *Tedania*, and this has influenced me in making my provisional identification.

The correct name of the East Indian species is doubtful too—an additional reason for hesitating to synonymize on the basis of a dubious resemblance. The oldest name that may possibly be available is *Spongia macrodactyla* Lamarck (1814: 458), but its use is beset with difficulties. Its locality is not certainly known; Lamarck himself was not sure, but thought it might be East Indian. Topsent (1933: 13) redescribes Lamarck's material, showing a spiculation like *Tedania*, but he adds that the skeleton is mostly keratose, and his photograph shows a general appearance that might well be that of a keratose sponge. Such forms often contain foreign spicules. If this one had no spiculiferous neighbors except *Tedania*, it might contain only *Tedania* spicules. If the spicules are proper, this is a peculiar *Tedania* because of its large spongin content.

Thiele in 1903 described four species of *Tedania* from the East Indies (Ternate, in the Molucca Sea). These are *reticulata* (p. 946), *coralliophila* (p. 946), *meandrica* (p. 947), and *brevispiculata* (p. 947). The differences in spicule size which Thiele emphasizes are within the range of individual variation and we may be confident that these, all from the one locality, are conspecific, to be known as *Tedania reticulata*. I wish to record at this time, that further studies in the East Indian region may bring about a decision to include the Hawaiian *Tedania* with *reticulata*, rather than with *ignis*. Undoubtedly some authors would designate the Hawaiian form as a new species and perhaps this may ultimately prove to be necessary.

KANEOHEA new genus

This genus is erected in the family Psammascidae with the following species, *Kaneohea poni*, as genotype. It should be emphasized that this is a genus (like all in the family) with a principal skeleton of foreign material, to which are added strongyles, oxeas, styles, and raphides. The genus which is most similar is *Holopsamma*, which has strongyles and styles but not the oxeas and raphides. Oxeas and raphides are each quite unusual in this family.

The generic name is given in honor of Kaneohe Bay.

Kaneohea poni new species

Fig. 14

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22751. It was collected January 10, 1948, at a depth of 1 meter, growing on dead coral in Kaneohe Bay. Only the one small specimen has so far been found, but it might be sought in the future with some interest.

This specimen is a thin encrustation, about the size and thickness of a shilling or quarter-dollar. The color in life was a brilliant, gaudy purple, one of the most conspicuous color notes one may hope to find. The consistency is mediocre. The surface is smooth, and, as might be expected, the specimen is lipostomous.

There is just the thinnest of fleshy ectosomes, less than 10 μ thick, which is very easily destroyed by handling. The endosome is packed with sand grains that are about 30 to 60 μ in diameter—so small that they would easily be swept about and carried in water currents. In among these grains there is an isodictyal proper skeleton, with some uniserial spicule tracts.

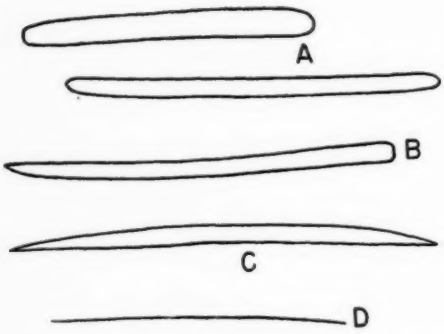

FIG. 14. *Kaneohea poni*, spicules, from a camera lucida drawing, × 666. A, strongyles. B, styles. C, oxea. D, raphide.

The spicules show little or no localization, but all three kinds of megascleres make up the reticulation, well mixed. The strongyles are about 5 by 90 μ, the styles 4 or 5 by 120 μ, the oxeas also 5 by 120 μ. The raphides are about 0.5 by 90 μ.

The species name is derived from the Hawaiian word for purple.

Mycale cecilia de Laubenfels

Fig. 15

This species is very common in Hawaii, widely scattered in shallow water locations. Its greatest abundance, however, seems to be in Honolulu Harbor and in Pearl Harbor. The first specimen that I found in Kaneohe Bay was at Moku O Loe, November 3, 1947; this is deposited in the U. S. National Museum, Register Number 22747. It occurred as a large encrustation on a mangrove shoot at location 2 in Figure 2. By December 22, 1947, the whole sponge had disappeared, although I had carefully left most of it *in situ*, and the location was one that would be most easily kept track of and found again. Nor have I been able to find it in that vicinity since. This may have some connection with a reproductive cycle.

This species is encrusting, often about 0.5 to 1 cm. thick. The above mentioned Moku O Loe specimen covered a mangrove shoot that was some 40 cm. long. The multitude of colors of this species requires further discussion below. The consistency is softly spongy.

The surface is fairly smooth, with many minute, contractile pores. The oscules are about 200 μ in diameter, but they too are difficult to measure because of their contractility and small size at greatest opening.

The ectosome is a definite dermis over extensive subdermal cavities. The endosome is a reticulation of spicular tracts 30 to 120 μ in diameter, often about 65 μ in diameter. Each is packed with spicules, and may possibly, but not certainly, contain spongin. Distally, each ends in a tuft or brush. There are astonishingly few interstitial megascleres.

FIG. 15. *Mycale cecilia*, spicules, from a camera lucida drawing, × 333. A, style. B, sigmas. C, palmate anisochelas.

The megascleres are tylostyles with long rather than wide heads; their sizes are 4 by 250 to 6 by 240 μ. The microscleres include commonplace sigmas 30 to 42 μ in chord length, and palmate anisochelas. These latter are very narrow, so that in boiled-out spicule preparations all lie on their sides. Profile views are thus common but what one may call "face views" are rare and difficult to find. In most specimens these spicules are only 15 μ long, but in some specimens they range to at least 24 μ. I found none in rosettes.

There are close to a hundred species names left in *Mycale*, even after the partitioning of the genus undertaken previously (de Laubenfels, 1936: 118). Only about 25 of these, however, have tylostyles rather than the usual styles as megascleres. The additional factor of very narrow anisochelas reduces the number still further.

Duchassaing and Michelotti (1864: 89) described *Pandaros angulosa,* and de Laubenfels (1936: 116) shows that it is a *Mycale.* This is a common West Indian species, and its spiculation is practically identical with that of the specimens which are now under consideration. It is, however, one of the fairly numerous species of *Mycale* that have the following distinctive characteristics: they are extremely coarse with gross chambers upwards of a centimeter in diameter; the flesh and skeleton are largely restricted to the trabeculate partitions. Upon handling a specimen, there is copious production of colloidal slime. I have observed a head-size specimen literally fill a tub with its exudate within 12 hours. *Mycale angulosa* itself has a pronounced tendency to assume a hollow or vasiform habitus.

In a study of the sponges of Panama, de Laubenfels (1936: 447) reported from the Pacific side, at Panama City, intertidal, the new species *cecilia.* This has a spiculation like that of *angulosa* and like our Hawaiian *Mycale,* but this species is encrusting, fine-grained, with few or no gross cavities even as much as 1 mm. in diameter, and scarcely a bit of colloidal exudate upon handling. But for the spicules, one would not consider *cecilia* and *angulosa* to be even in the same family.

The identification of the *Mycale* from Hawaii is complicated by the peculiar color situation. The Panama specimens of *cecilia* were all green, one of the few colors never shown by the Hawaiian specimens. Furthermore, in July and August, 1933 (when I studied it in the field), it was thickly beset with bright red embryos about 200 μ in diameter. These showed plainly in a specimen held 2 meters away—a bright green but red-speckled and thus curiously conspicuous sponge. In contrast, the Kaneohe specimen above described was a mottled patchwork of pink and lavender. In November, 1947, it was loaded with yellow embryos, 600 μ in diameter, and these did not show at all from the surface, but were all in a layer at the base of the sponge and adjacent to the mangrove tissue upon which it was growing. May not such differences in size and color of embryo and color of adult tissue indicate specific difference? Yet this is further complicated by the finding in October and also in March of yellow to orange colored specimens devoid of embryos.

Just as a surmise, a hypothesis to be checked by later field observation, one may wonder if the young embryos are red, changing to orange and then yellow as they enlarge, and if perhaps the young sponge is yellow, then pale orange, then pink, and at last lavender just when reproducing. It may die after giving off a large number of embryos, at an age between 1 and 2 years. This is not groundless surmise, as it is also partially confirmed by some observations of mine upon related species at Bermuda. The green color found at Panama might well be due to the presence of algal symbionts.

Zygomycale parishii (Bowerbank) Topsent

Fig. 16

This species was first collected from Kaneohe Bay at Moku O Loe, on the shore of the harbor, north of location 6 (Fig. 2) at a depth of 2 meters. This specimen is deposited in the U. S. National Museum, Register Number 22735. It is one of the commonest species at Moku O Loe, but rare or absent elsewhere in Kaneohe Bay. It is extremely abundant as a growth on vessels that remain for a year or so at harbor on the lee side of Oahu, as revealed by study of ship bottoms in the dry-docks at Pearl Harbor.

This is a somewhat ramose sponge; there is an amorphous basal mass from which long processes arise. These processes are extremely irregular in cross section and in long section, too. This is another species of many colors. Probably the commonest is a dull reddish or brownish-purple. Individual specimens are

often polychrome, gradually shading into different hues here and there without apparent relationship to ecological factors or anything else. A few specimens are bluish-violet to gray. The first collected was definitely orange. I found no green, yellow, black, white, or any brilliantly colored specimens of this sponge. One might say that the color ranged from dull orange through mahogany-brown to dull lavender. The consistency is spongy. If any considerable quantity is available, say a good handful, one may discover that this species has a definite odor. I have never found a similar fragrance in any other sponge, nor failed to find it in *Zygomycale*—some half a dozen times that a large quantity was at hand. This odor is strongly reminiscent of linseed oil, also faintly suggestive of fresh-cut grass, not like phosgene, but much more like old, oxidizing linseed oil.

The surface of this species is rather smooth but not level, and has a very characteristic speckled or punctiform appearance by which one soon comes to recognize it. This is due to a dermal network of fibers. The latter are minute, only about 5 to 10 μ thick, and the meshes are 65 to 100 μ in size. However, even when the unaided eye cannot resolve the individual pores or fibers, the over-all appearance can be recognized. The oscules are about 2 or 3 mm. in diameter, often provided with thin, raised rims. They are uncommon and rather difficult to find among obviously accidental surface openings.

The ectosome is a definite dermis over extremely widespread, nearly omnipresent subdermal spaces which may be as much as 0.5 mm. high. It contains the special network already mentioned. The endosome contains a coarser, but still rather fine-grained, network of fibers; these fibers are upwards of 50 μ in diameter and contain about 15 spicules per transverse section. At their distal terminations they splay out into dermal brushes or tufts.

The megascleres of *Zygomycale* are of one

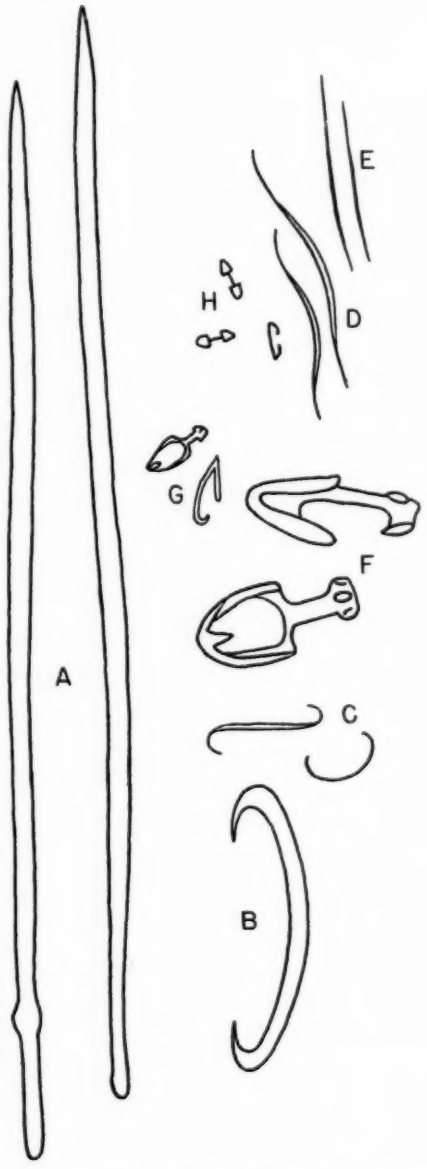

FIG. 16. *Zygomycale parishii*, spicules, from a camera lucida drawing, × 666. A, styles. B, larger sigma. C, smaller sigmas. D, toxas. E, raphides. F, larger palmate anisochelas. G, smaller palmate anisochelas. H, palmate isochelas.

kind only, a subtylostyle with such a vague neck constriction that it is barely perceptible; therefore they often give a first impression of being styles. The microscleres are extremely diversified. Only the genus *Acarnus* can match this one for diversity of small spicules. There are large palmate anisochelas, 40 to (more usually) 48 μ long, and often grouped in rosettes, small ends together in the center of a spherical arrangement of the larger ends. There are medium-sized palmate anisochelas, 18 to 20 μ long. There are minute palmate isochelas only 10 μ long. There are two sizes of sigmas—the larger, 5 μ in diameter and from 75 to as much as 90 μ in chord length; the smaller, 25 to 30 μ in chord length, and only 1 or 2 μ thick like most sigmas. There are toxas 30 μ long, and, rarely, also raphides barely 10 to 15 μ long. They may be more common than first appears, but often overlooked because of their minute size—they are hardly as much as 1 light-wave in diameter.

The genus *Zygomycale* was established by Topsent (1930: 431). The genotype is here designated as the sponge which was first described as *Raphiodesma parishii* by Bowerbank (1875: 283), the name here selected with some misgivings for the Hawaiian *Zygomycale*. Topsent transferred three other species names to his new genus, but two additional ones still require such transfer. They are the species first described as *Esperella ridleyi* by Lendenfeld (1888: 211) and that described as *Esperella crassissima* by Dendy (1905: 160). The original description of *parishii* by Bowerbank is utterly inadequate, and its use here rests entirely upon this circumstance. Burton and Rao (1932: 328) state that it is their opinion that *parishii* and several others now in *Zygomycale* are all conspecific. It is probable that Bowerbank's specimen of *parishii* is in the British Museum; therefore it is probable that Dr. Burton examined it. It is further probable that he really did find it to be conspecific with the others because of his treatment thereof, above mentioned. If so, *Zygomycale* is monospecific. All the records have been from the eastern part of the Indian Ocean, the East Indies, and Australia; therefore the possibility of conspecificity is great. Thus there may be a link between the East Indian fauna and that of Hawaii, evidenced by the occurrence here of *Zygomycale parishii*.

Hymeniacidon chloris new species

Fig. 17

The holotype of this species is here designated as spirit-preserved specimen, U. S. National Museum, Register Number 22738. It was collected September 11, 1947, at Moku O Loe, from a depth of 1 meter (location number 1, Fig. 2). It is fairly common at that one locality but has not been found anywhere else as yet.

This species forms masses ranging from the size of a hen's egg to that of a small fist. Numerous tapering projections 1 to 2 cm. high and 6 to 14 mm. thick occur. The color is a medium dark green; the consistency is soft, somewhat spongy, but also rather fragile.

The surface is minutely tuberculate. The oscules are 1 to 2 mm. in diameter, usually at the summit of one of the above-described processes, and are readily closed by the sponge within less than 5 minutes after removal from the water. The pores are even more rapidly closed. They are often in groups of 8 to 12, separated by only very thin strands; these groups are about 200 μ in total diameter.

The ectosome is fleshy, contractile, a true dermis, perhaps 15 μ thick. The endosome is rather dense, and is packed with spicules. The latter are sometimes loosely organized into strands; more have their points toward

FIG. 17. *Hymeniacidon chloris*, spicules (styles), from a camera lucida drawing, × 296.

the surface than any other orientation, but many are strewn in confusion.

The spicules are exclusively styles, chiefly 5 by 300 to 7 by 400 μ in size. A few that are much smaller may be immature.

One hesitates to erect a new species in a genus that, like this one, has fifty names in it already, especially since these are all so much alike in description. On the other hand, this genus has only a few of those traits to which we look for specific separation; were we to consider others, such as chemical composition, serological reaction, and physiological processes, we might find that there really are more diverse species within it than are now suspected. The emphasis is here laid on the green color. Bowerbank (1874: 191) established the name *Hymeniacidon plumiger* for two British specimens that he said were green in preservative; what they were in life is unknown. He may have overlooked microscleres; therefore we are not sure that these specimens were even of the genus *Hymeniacidon*. Their styles were only 4 by 234 μ. Since Bowerbank's report, no one seems to have found any further specimens to match his description; therefore *plumiger* is not an important species name, and, except for this dubious record, the color is unique in the group. Except for the color, *chloris* is much like *Hymeniacidon heliophila*, which is abundan on the Atlantic coast of North America. It must be realized that green color may be due to contained algal symbionta; even so, that a species should specialize in symbiosis may be a valid criterion.

It appears that there are the following valid species of *Hymeniacidon* in the world: a yellow one, *caruncula*, in the Mediterranean and north to England; a deep red one, *sanguinea*, from England on north (some experts would synonymize these, but I found them both at Plymouth, England, and definitely decided they were not conspecific); an orange species, *heliophila*, from the Arctic to the West Indies in the West Atlantic; a yellow species, *sinapeum*, which is practically undistinguishable from *caruncula*, on the west coast of North America; in the same locality also occurs *ungodon* with a peculiar mahogany colored ectosome. In the West Indies *amphilecta* has a curious brown color and corky consistency. Five species names occur in the Indian Ocean and East Indies; all have extremely thick spicules (20 to 40 μ) and may all be conspecific. A yellow species, *fernandezi*, from both coasts of South America, is also close to *caruncula*, but *paucispiculus* from Argentina is not certainly of this genus; it is a fan with few spicules and those are of two size ranges. Three species names have been used in this group for New Zealand forms; all three are much alike and may be conspecific; minute differences separate them from *caruncula*. Four Antarctic species each have some distinctive peculiarity, such as centrostyle spicules, or verrucose surface. Many other named species are unrecognizable or are already known to fall in synonymy. Assuming *chloris* to be a good species, I opine that there are 14 valid species in the genus.

The species name *chloris* refers to the green color of this sponge.

Terpios zeteki (de Laubenfels)

Fig. 18

This species is one of the two or three most abundant sponges in Hawaii. My first specimen from this region was collected September 10, 1947, at Moku O Loe at a depth of 1 meter, near the pier (location number 6, Fig. 2). This one is deposited in the U. S. National Museum, Register Number 22739.

This species is sub-ramose. There is a basal mass from which rounded projections arise, often scarcely more than hemispherical, at other places digitate. These projections are usually between 1 and 2 cm. in diameter, from 0 to 5 cm. long. Some masses reach head size. The interior of *zeteki* is consistently an ochre-yellow, but the exterior is con-

trastingly colored. In the type of the genus, *fugax*, the yellow shows over more or less of the surface, the rest being a dark prussian blue. In *zeteki* the yellow never shows and the whole exterior is of one uniform color. This color in nearly 50 per cent of all specimens is a turquoise or robin's-egg blue, in as many other specimens it is rosy-red. This was the color of the above-mentioned U. S. National Museum specimen. After a long search, out of scores of specimens, I began finding an occasional one that was violet—clearly a hybrid of the other two colors. I never found a parti-colored colony but always the entire sponge of the same hue. The consistency is spongy.

The surface of *Terpios zeteki* is tuberculate, almost like the skin condition called "goose pimples." The elevations are less than 1 mm. high and about 3 or 4 mm. apart. The pores are extremely contractile, and so are the oscules, but in life the latter certainly open to as much as 2 mm. in diameter. Their closure is by a sphinctrate contraction involving rather typical muscle cells instead of by the pulling of a membrane across the opening as in some sponges. This muscular closing is quite typical, however, of the order Hadromerina, in which this genus belongs.

The ectosome of this species is very thin, not the usual thick cortex of this order; in fact, it is usually less than 50 μ thick, and chiefly organic. The endosome is so densely organic as to resemble cheese; the gross chambers carry out the similarity. There is no segregation of spicule sorts nor any conspicuous tracts. Most of the spicules are in confusion but more have their points toward the surface than with any other one orientation. There are vague ascending tracts, and these end in relatively large, very definite dermal tufts or brushes; in these tufts the spicules bristle, all the points being directed toward the surface or slightly divergent.

The spicules are exclusively tylostyles, of great variation in size. Many are about 4 by 300 μ, but 14 by 700 may be expected; many are only 2 (or less) by 200 μ. An interesting shape is often found in the slender, unfinished spicules of this species, especially if the whole colony be small and evidently young. In such spicules it can be seen that the head is not just one single swelling, but is due to the existence of four short arms at right angles to each other and to the rhabd or shaft. Such a spicule could be called an orthotetraene; in the Hyalospongiae it is called a pentact. These four arms in *Terpios* do not continue to grow; they stop when only about 1 μ long and are then buried by successive layers of the opaline silica. When the mass of the head reaches a diameter of about 4 or 5 μ, the arms are so thoroughly covered that they can no longer be observed. The genus *Terpios* was based upon the occurrence of these pentactinal spicules; the larger, older specimens were put in a later genus *Laxosuberites*. In a manuscript on the sponge fauna of Bermuda I show the synonymy of the two, and review the genus *Terpios*; that manuscript may be published before this one.

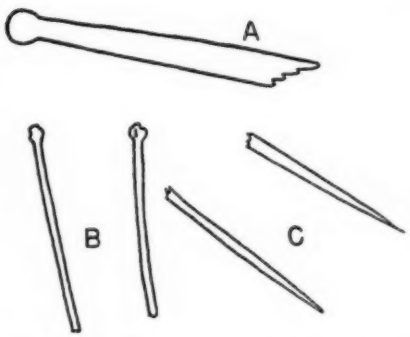

FIG. 18. *Terpios zeteki*, spicules, from a camera lucida drawing, × 666. A, the head of one of the common spicules, which are tylostyles. The pointed end, not shown, is commonplace. B, heads of some smaller (juvenile?) tylostyles, which show the hexactinellid pattern. C, pointed ends of the spicules shown at "B"; the mid-regions of them are not shown.

The present species was first described as *Laxosuberites zeteki* by de Laubenfels (1936:

450) from the vicinity of the Panama Canal, especially the Pacific end. The amazing color situation was evident there, half of all the specimens being red, the remaining ones blue-green. In Panama I found no intermediates. Dickinson (1943: 37) records the species from the Pacific coast of Mexico. This species and *Mycale cecilia* afford links between the Hawaiian fauna and that of the tropical Americas.

Cliona vastifica Hancock

Fig. 19

This species was first studied in Hawaii on September 27, 1947, in Waialua Bay (northwest of Kaneohe Bay), at a depth of about 3 meters. This specimen is deposited in the U. S. National Museum, Register Number 22743. The species is common throughout the shallow waters of Hawaii, but is always inconspicuous. If one breaks up almost any long-submerged calcareous material, such as shells or dead coral, one will find this boring sponge. It is very common throughout Kaneohe Bay.

Cliona vastifica excavates galleries in calcium carbonate. These are roughly circular in cross section and about 1 mm. in diameter. Each gallery meanders rather than extends in a straight line, and may reach a total length of 5 to 10 cm. Old coral may be so riddled by *Cliona* that it crumbles as one handles it, but this is not common experience in Kaneohe Bay, where usually a crowbar or hammer is required to break up the coral. The sponge is orange in color, and of mediocre consistency. The pores and oscules are minute, and are located at the small inconspicuous openings to the galleries (1 mm. in diameter). Obviously one can say little about ectosome as compared to endosome as long as the sponge lives thus buried. *Cliona* specimens may grow out of their burrows into plain view, but I have not yet found any such in Hawaii. The principal skeleton of *Cliona vastifica* consists of tylostyles 4 by 300 to 7 by 240 μ in size. Fairly numerous microspined oxeas, 4 by 85 to 5 by 75 μ, are also present. There are distinctive microscleres, heavily microspined and probably to be regarded as microstrongyles, but the ends are cut off so sharply that they are more like little cylinders. Some are as small as 2 by 8 μ, others as large as 3 by 18 μ, with 10 μ as a common length.

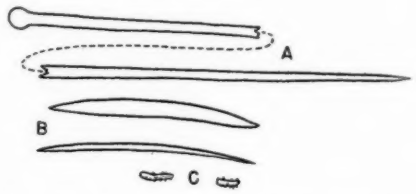

FIG. 19. *Cliona vastifica*, spicules, from a camera lucida drawing, × 444. A, tylostyles. B, oxeas. C, microacanthostrongyles.

This species was first described by Hancock (1849: 342) from Great Britain. It is an abundant species throughout the Old World, but quite uncommon (although present) in the New World. In the Americas the boring sponges are nearly always *Cliona celata*; this species is also common in the Old World, but from Norway, to Turkey, to Ceylon, to New Zealand, *vastifica* is a close rival to *celata*. Is *vastifica* perhaps a recent immigrant to North America, carried by barnacles on ship bottoms? Did it reach Hawaii in that same way too?

Tethya diploderma Schmidt

Fig. 20

This species is very common throughout the shallow waters of Hawaii, including Kaneohe Bay. It is represented by some specimens collected November 22, 1947, at Moku O Loe, at a depth of 1 meter, in the long lagoon (location number 3, Fig. 2). These are deposited in the U. S. National Museum, Register Number 22751.

This species is nearly spherical in shape and may become as large as a hen's egg; more

often it is about half this size. The interior is regularly ochre-yellow. The exterior is extremely pale, almost white for specimens that grow in the shade, but a mahogany-brown for specimens which grow in relatively bright illumination. This was true of most of the Moku O Loe specimens. Among the brown tethyas, however, were a few that in life appeared black. In alcohol these promptly bleached to about the brown color that the others had in life, but the brown ones in alcohol bleached very pale indeed. The black specimens had identical spiculation, and in all respects, save for color, appeared to be identical with the brown ones. No difference in their ecological placement could be found to account for the difference in hue. The hypothesis here favored is that the black ones had a symbiont of some sort in or on their dermis, which symbiont was lacking from the brown tethyas. The consistency of this sponge is cartilaginous.

The surface of *Tethya* changes with the reproductive cycle, but is always more or less verrucose. The protrusions are at the distal terminations of spicular fascicles, and are about 2 mm. in diameter. Their height varies during the reproductive cycle from nearly 0 to more than 3 mm. so that they may actually depart from the parent as slowly motile buds. The pores and oscules are very contractile but the latter may open to as much as 2 mm. in diameter. There is seldom more than one oscule per sponge, and it is usually apical.

Schmidt's name *diploderma* is well deserved by the remarkable ectosome of this sponge. The outer cortex is about 650 μ thick, and may contain symbionts, reproductive tissue, and protective tissue including microscleres. The inner cortex is about as thick or a little thicker, is pale, full of strong smooth muscle tissue, and very contractile. Not only may the pores and oscules be closed promptly, but the whole sponge seems to grow smaller when these muscle fibers contract.

The endosome is rather dense, and is permeated by radiating columns or tracts of megascleres; each tract is about 200 μ in diameter. There is one column for each dermal protrusion.

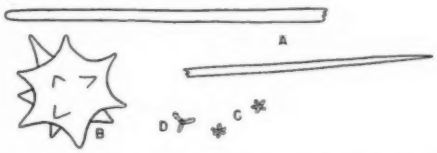

FIG. 20. *Tethya diploderma*, spicules, from a camera lucida drawing, × 333. A, style or fusiform strongyle. B, spheraster. C, small tylasters, common shape. D, euaster, less common shape.

The megascleres are inequiended, fusiform strongyles. The small end is usually pointed toward the surface of the sponge and is so small that the spicule almost becomes a style. Indeed, some actually appear to be genuine styles. They range in size from 8 by 500 μ up to at least 20 by 1500 and 25 by 1250 μ. There are two sorts of microscleres. First, there are large spherasters, 25 to 75 μ in diameter, more often near the larger size. These are chiefly localized just under the cortex. Second, there are myriads of small tylasters with microspined rays. The total diameter of the asters is only 5 to 11 μ. They are abundant both in the outer cortex and throughout the endosome.

This species was first described by Schmidt (1870: 52) from the West Indies, but has since been shown, especially by Burton (1924: 1039), to be practically cosmopolitan. A very interesting article by Edmondson (1946: 271 and following) discusses the asexual reproduction of this species as it occurs in Hawaii, but uses the name *Donatia deformis*. The name *Donatia* is a later synonym for *Tethya* but was used for a while on the unwarranted assumption that the still earlier name *Tethys* (for a mollusk) preoccupied Lamarck's (1814: 69) establishment of *Tethya*. The two names are, of course, quite different. The species *deformis*

is much like *diploderma* but less elaborate as to dermis, and its microscleres each have a centrum. It is a western Pacific species, from Japan through the East Indies to New Zealand. The species *diploderma* is circumequatorial. If the two should be determined to be conspecific, as is possible, the name *diploderma* has a 28-year priority.

ZAPLETHEA new genus

This genus is erected with the following species, *Zaplethea digonoxea,* as genotype. It is placed provisionally in the family Halinidae, subfamily Corticiinae. It should be emphasized that this is a genus of sponges with extremely abundant microscleres, but very few megascleres, those that are present being oxeas. The microscleres are of two sorts, euasters and twice-bent microxeas.

Twice-bent spicules are exceedingly rare in the phylum Porifera. There is at least one other case, however. This is the record by de Laubenfels (1930: 26; or better, 1932: 35) of *Penares cortius,* a sponge with two kinds of microscleres: euasters and twice-bent microstrongyles. It had a few oxeate megascleres, so that if the twice-bent spicules were oxeate, there would be agreement to this extent. However *Penares* has a principal spiculation of large tetraxons; thus it goes in the order Choristida. *Penares cortius,* from California, was a large sponge with a conspicuous leathery dermis, very different in appearance from *Zaplethea digonoxea.*

In the order Choristida there is a family Jaspidae. Its type genus, *Jaspis,* has a spiculation of oxeas and euasters, but no twice-bent microscleres; the oxeas are the principal spicules, and are radiately arranged. These are large, significant differences from *Zaplethea.*

The order Carnosa is established especially to receive sponges that have few or no megascleres, and has even been called "Microsclerophora." Thus it seems clearly to be the best order to receive the genus *Zaplethea.* Yet the family situation in this order is still perplexing; there are now four families in the Carnosa, and none quite fits *Zaplethea.*

The Chondrosiidae have no spicules at all.

The Chondrillidae have only euasters.

The Plakinastrellidae have a few megascleres, as no others in the order do, and thus are intermediate. But the megascleres that are present are tetraxons, so that the intermediate condition obtains as between the Carnosa and the Choristida. For lack of tetraxons, *Zaplethea* seems utterly out of place in the Plakinastrellidae.

The fourth family is the Halinidae, here selected by elimination. Yet all the genera of this family (there are about a dozen) have a peculiar microsclere known as calthrops. Other than this, these genera are divided into two subfamilies; the Halininae have asters that are streptasters, while the Corticiinae have asters that are euasters.

If we focus attention on the above-mentioned fact that every other genus in this family has calthrops, and regard this as a reason for excluding *Zaplethea,* we are thrown into the embarrassing situation of needing a new family to receive this genus. I do not want to erect any more families in the Porifera, because I believe there is a large enough number already.

The genus name is derived from the Greek "zaplethes," meaning very full, because the sponge is so packed with spicules. The exact Greek is not available, having been used in 1868 in Hymenoptera, also in 1920 in Pisces.

Zaplethea digonoxea new species

Fig. 21

The holotype of this species is designated as spirit-preserved specimen, U. S. National Museum, Register Number 22746. It was collected September 27, 1947, in Waialua Bay, at a depth of between 4 and 8 meters, growing on dead coral. A second specimen was collected in Kaneohe Bay on January 10,

1948, at a depth of 2 meters, also on dead coral.

This species is encrusting, about 3 to 5 mm. thick. The color is pale, dull, and may be termed drab, or yellowish-gray. The consistency is firm, somewhat like cartilage. The surface is smooth and lipostomous. There is no sharply defined cortical region. The interior is exceedingly dense, with few cavities larger than 40 μ in diameter. The flagellate chambers are about 25 μ in diameter.

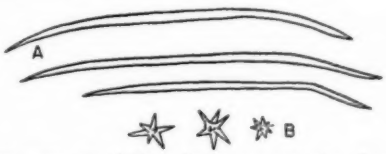

FIG. 21. *Zaplethea digonoxea*, spicules, from a camera lucida drawing, × 444. A, microxeas. B, euasters. The larger oxeas are not shown.

There are a few scattered oxeas, 7 by 400 to 12 by 520 μ in size. They are so rare that while I had only the one specimen I considered them accidental, foreign inclusions. But they were not only present in the second specimen, they were a little more nearly common in it. The whole sponge is densely packed with millions of microscleres. They are of two sorts, about equally abundant. One kind is an oxyeuaster, usually 10 μ, but ranging on up to 20 μ, in diameter. The other very distinctive kind is a twice-bent microxea. The three straight regions make obtuse angles and are not quite equal in length; instead the middle piece is a little longer than the others. The over-all length is about 105 μ and the thickness 3 μ or less.

The species name stresses the twice-bent microxea; in fact, this novel sort of spicule itself may suitably be named digonoxea.

Plakortis simplex Schulze

Fig. 22

This species was found in Hawaii on January 10, 1948, in Kaneohe Bay, at a depth of about 2 meters, growing on dead coral. Another specimen was found on May 15, 1948, at Keaukaha near Hilo on the island of Hawaii, just below low tide mark.

This is a thin, encrusting sponge, seldom much more than 2 mm. thick. The two specimens covered about 10 square cm. each. The first was dull olive-brown, the second dull gray—this species is usually brown, but dull or drab. The consistency is rather like that of cheese.

The surface is smooth but not level, being often elevated into low tubercles. As usual in such thin sponges, it is lipostomous. There is a paper-thin fleshy dermis; the rest of the sponge is also very dense. It is astonishingly full of flagellate chambers which are round and are 30 to 40 μ in diameter. The spicules are crowded throughout the flesh in confusion. Much of the skeleton is merely the usual interstitial jelly.

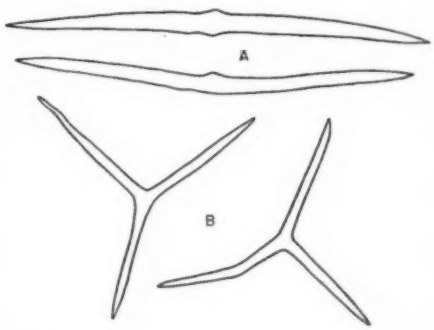

FIG. 22. *Plakortis simplex*, spicules, from a camera lucida drawing, × 380. A, oxeas (?). B, triaxons.

The spicules of *Plakortis* are chiefly to be regarded as triacts, and about one in twenty is indeed a neat, symmetrical triact as in calcareous sponges. The rays are often about 5 to 7 by 100 μ. More common are spicules that show signs of being a triact with one ray missing, so that the result is V-shaped. Very much the commonest of all are spicules that seem at a casual glance to be oxeas, but which have a central swelling or series of

kinks, so that they are probably triacts with one ray lost and the other two brought into nearly the same line.

This species was first discovered by Schulze in the Mediterranean (1880: 430). Someone (Dendy, I believe) found it again in an East Indian collection. I have found it in the West Indies (Tortugas) and in Bermuda, and now in two places here. It is probable that it is not so rare as it is simply overlooked because of being dull, drab, and thin; one might say it is camouflaged on the rocks that it normally inhabits.

Leucetta solida (Schmidt) Dendy and Row

Fig. 23

In Kaneohe Bay in particular, and throughout the Hawaiian Archipelago in general, small fragmentary calcareous sponges are very commonly found, usually growing on dead coral in shallow water, but also down to at least 50 meters depth (in my experience). These fragments are chiefly of a species that is clearly a *Leucetta.* A few calcareous sponges that are of other genera have been found in the Archipelago, but not yet in Kaneohe Bay.

The genus *Leucetta* is outstanding in the class Calcispongiae for its morphological resemblance to those sponges that are typical of the class Demospongiae. Most calcareous sponges have symmetrical, cylindrical shapes, with large central cloacal hollows, so that they are somewhat like the sponges of the class Hyalospongiae. It is common to find *Leucetta* species that are taken for Demospongiae until the acid test is applied to the (calcareous) spicules.

The genus *Leucetta* is cosmopolitan, especially common in the Antarctic and also in equatorial waters around the world. Some 18 species are commonly recognized. Of these, a few are unique; a new genus may indeed be needed for *Leucetta trigona.* Many others are separated by very small differences and may eventually prove to be conspecific.

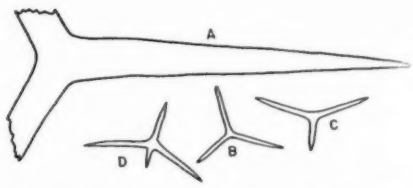

FIG. 23. *Leucetta solida* (?), spicules, from a camera lucida drawing, × 333. A, portion of one of the larger triaxons. B, common triaxons of smaller size. C, alate triaxon. D, tetraxon.

I do not yet have material adequate for a proper evaluation of the Hawaiian *Leucetta,* unless it be a specific characteristic that it should always seem to be just a fragment of a sponge. These specimens are usually amorphous, about as large as beans, white, fragile, and full of triaxon spicules of two size ranges. These traits are true of practically all species in the genus. The larger spicules have rays 100 to 120 μ thick and 660 to 960 μ long and thus are visible to the unaided eye. The smaller ones have rays 6 to 10 μ thick and 70 to 110 μ long. A few intermediates are probably developmental forms of the larger size range. I found one lone tetraxon, of the smaller size range. This may have been an accidental malformation, or an accidental (foreign) inclusion. Again, one must note that many calcispongias have such spicules in the lining of a cloaca, but not elsewhere. I have not yet found a cloaca in a specimen which is for certain one that occurs in Kaneohe Bay; however, it may be that a cloaca is part of this sponge's full complement of traits, and will be discovered later. On March 29, 1948, I found a calcisponge on the bottom of a barge in dry dock at Pearl Harbor. It had a cloaca lined with small tetraxons. It may or may not be the *Leucetta* that is locally widespread; more study is required.

Of all the species names available in the genus *Leucetta,* the oldest is *solida.* Schmidt (1862: 18) described *Grantia solida* from the Mediterranean. Dendy and Row (1913:

734) correctly transferred this to *Leucetta*. Schmidt's description is so generalized that many other *Leucetta* species could be put with it, and thus our Hawaiian *Leucetta* may be tentatively identified. It is here left an open question whether or not several later species names should be dropped in synonymy to *solida*.

Needless to say, this Hawaiian calcisponge does not help in determining faunal relationships to others parts of the world.

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Chromosome Numbers of Some Species of *Passiflora* Occurring in Hawaii[1]

W. B. STOREY[2]

INTRODUCTION

PASSIFLORA IS A GENUS of approximately 400 species of plants, mostly woody or herbaceous vines. About 360 species are native to tropical and subtropical North and South America and adjacent islands. The remainder are indigenous to southeastern Asia, a number of south Pacific islands, and Madagascar (Killip, 1938: 9). Man has been instrumental in disseminating many of the species with edible fruits or with highly colored, attractive flowers, and representatives of the genus are now to be found in most tropical lands throughout the world.

Several species of *Passiflora* have been introduced into the Hawaiian Islands for cultivation for their edible fruits (Pope, 1935). Additional species have been introduced for growing as garden ornamentals. A number of species, both edible and ornamental, have escaped from cultivation and are now to be found in a naturalized wild state along waysides, on waste lands, and in lower forest regions (Pope, 1929: 149). A total of 22 species has recently been reported as occurring in Hawaii (Neal, 1948: 522–525).

A number of edible species, of which *P. edulis* is the most important, are cultivated as commercial crops in Australia, New Zealand, and South Africa, where extensive use is made of the fruit. Their culture is practiced to a lesser degree in various other tropical countries, and in Florida, California, and Hawaii. Numerous ornamental species and species-hybrids constitute an important item in the plant nursery business in the United States and elsewhere.

Nurserymen have enjoyed some success in producing interspecific hybrid varieties for the floricultural trade. Fruit breeders, on the other hand, have had little or no success in attempts to improve upon existing edible types through interspecific hybridization, largely because of hybrid sterility.

Cytological studies of plants often serve as a useful adjunct to plant breeding problems. Chromosome numbers and chromosome behavior frequently indicate origins of species and relationships between species, and provide clues as to which species are most likely to be compatible upon crossing. Despite the amount of breeding which has been done among species of *Passiflora,* in Hawaii and elsewhere, the genus is but poorly understood from the standpoint of cytology. The recently published *Chromosome Atlas of Cultivated Plants* lists the chromosome numbers of only seven species (Darlington and Janaki Ammal, 1945: 114).

This paper deals principally with reporting the chromosome numbers of additional species of *Passiflora* as well as of a number of botanical varieties and forms, interspecific hybrids, and an intraspecific chromosomal race. Notes on cytological behavior have been added where they might be helpful in clarifying origins or relationships.

MATERIALS AND METHODS

Chromosome numbers were determined for all species of *Passiflora* of which material for study could be obtained in Hawaii. Counts were made from root tips of seedling plants

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[2] Department of Horticulture, University of Hawaii Agricultural Experiment Station. Manuscript received May 24, 1949.

or rooted cuttings, and, whenever possible, from suitable flowering material. Root tips were stained by the crystal-violet–iodine method following Randolph's (1935) schedule. Anthers from young buds were examined in smear preparations with the use of iron-acetocarmine (Belling, 1926).

The figures were drawn with the aid of a camera lucida.

OBSERVATIONS

All species and subspecific forms for which chromosome numbers have been determined are listed in Table 1. They are placed in the table in the order in which they occur in Killip's (1938) systematic treatment of the genus. Interspecific hybrids which are not included in Killip's treatment are placed at the bottom of the table. The list comprises 16 species, 1 botanical variety, 4 botanical forms, 4 interspecific hybrids, and a polyploidal race of one species.

Six of the seven species listed in the chromosome atlas of cultivated plants (Darlington and Janaki Ammal, 1945: 114) are reported to occur in Hawaii (Neal, 1948: 522–525). These species are *P. caerulea* L., *P. edulis* Sims., *P. foetida* L., *P. incarnata* L., *P. quadrangularis* L., and *P. racemosa* Brot., all of which are reported to have chromosome numbers of 2n = 18. The seventh species, *P. lutea* L., with a chromosome number given as "2n = 84?," is not known to be in the islands. Of the 22 species listed by Neal (loc. cit.), the writer was unable to obtain material of the following seven: *P. alata* Dry., *P. coccinea* Aubl., *P. antioquiensis* Karst., *P. kermesina* Link and Otto, *P. racemosa* Brot., *P. Banksii* Benth., *P. fruticosa* Killip.

TABLE 1

CHROMOSOME NUMBERS OF VARIOUS SPECIES, SUBSPECIFIC FORMS, AND INTERSPECIFIC HYBRIDS OF *Passiflora*

PASSIFLORA SPECIES	CHROMOSOME NUMBER	
	N	2N
P. suberosa L.	12	24
P. suberosa (triploid)	18*	36
P. lutea L.	----	84?†
P. pulchella HBK	6	12
P. mollissima (HBK) Bailey	----	18
P. manicata (Juss.) Pers.	----	18
P. vitifolia HBK	9	18
P. quadrangularis L.	----	18
P. ligularis Juss.	----	18
P. Seemanni Griseb.	9	18
P. maliformis L.	9	18
P. laurifolia L.	9	18
P. incarnata L.	----	18
P. edulis Sims	9	18
P. edulis form *flavicarpa* Degener	9	18
P. caerulea L.	9†	18†
P. subpeltata Ortega	9	18
P. foetida L.	10	20‡
P. foetida (3 variant forms)§	10	20
P. foetida variety *gossypifolia* (Desv.) Mast.	10	20
P. Pfordti (= *alata* Dry. × *caerulea* L.)	----	18
P. maliformis L. × *laurifolia* L.	----	18
×*P. caerulea* L. (hybrid) (Degener, 1934)	----	18
P. princeps-coccinea (= *racemosa* Brot. × *coccinea* Aubl.)	9†	18†

* Some meiotic irregularity.
† Reported in *Chromosome Atlas* (Darlington and Janaki Ammal, 1945: 114); not seen by author.
‡ Reported as 2n = 18 by Janaki Ammal (Darlington and Janaki Ammal, 1945: 114).
§ Variety or form names, if any, not determined by writer.

On the basis of somatic chromosome numbers which are reported in Table 1 and of numbers previously reported in the literature, all of the species, hybrids, and varieties investigated to date may be classified into six chromosome number groups. These groups and the species belonging to them are as follows:

2n = 12—*P. pulchella*

2n = 18—*P. mollissima; P. manicata; P. vitifolia; P. quadrangularis; P. ligularis; P. Seemanni; P. maliformis; P. laurifolia; P. maliformis* × *laurifolia; P. racemosa; P. coccinea; P. racemosa* × *coccinea; P. incarnata; P. edulis; P. edulis* f. *flavicarpa; P. alata; P. caerulea; P. alata* × *caerulea (Pfordti);* × *P. caerulea; P. subpeltata; (P. foetida ?).*

2n = 20—*P. foetida,* and 3 variant forms; *P. foetida* var. *gossypifolia.*

2n = 24—*P. suberosa*

2n = 36—*P. suberosa*

2n = 84?—*P. lutea*

The 2n = 12 group consists of but a single species, *P. pulchella.*

The 2n = 18 group comprises 15 species, 4 interspecific hybrids, and 1 botanical form, with 1 species doubtful. Janaki Ammal (loc. cit.) determined the somatic chromosome number of *P. foetida* to be 18. The writer, on the other hand, has examined considerable material of *P. foetida,* its botanical variety *gossypifolia,* and several variations, all of which occur as common wayside weeds in Hawaii, and has never failed to find 20 somatic chromosomes (Fig. 1). Examinations of dividing sporocytes have consistently revealed 10 bivalents normally paired (Fig. 2). The writer, therefore, is disposed to place *P. foetida* in a separate group consisting only of itself and its varieties. The possibility is not excluded, however, that the Hawaiian representatives of the species may be aberrant forms. *P. foetida* probably was limited to a single introduction from which all of the plants presently populating the several islands are derived.

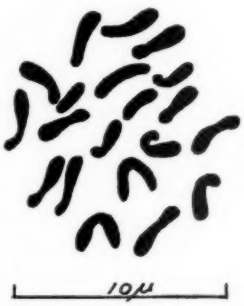

FIG. 1. Mitotic metaphase in *P. foetida* root tip showing 20 somatic chromosomes.

FIG. 2. Meiotic metaphase I in *P. foetida* showing 10 bivalent chromosomes.

Microsporogenesis was observed to proceed along a normal course in all of the species in the 2n = 18 group. A single exception was noted in *P. subpeltata,* in which syndiploidy occurred in one locule of an anther. The sporocytes in this locule were seen at diakinesis to have 2 large nucleoli and 18 pairs of associated chromosomes instead of the usual 9 pairs. There seemed to be no strong tendency to form multivalent configurations, and it is supposed that such sporocytes would have proceeded to give rise to diploid microspores. The condition very probably arose through failure of a mitotic anaphase in the meristem from which the sporogenous tissue was derived.

Pope (1935: 11) proposed a hybrid origin for *P. edulis* f. *flavicarpa,* possibly as a cross between *P. edulis* and *P. ligularis.* The supposition is not borne out in studies of cytological behavior, for meiosis is normal in every respect (Fig. 3), and both the ovules and the pollen grains are fully viable. The

chromosome number of 18 shows that the plant is not a double diploid, and, therefore, in view of its full fertility, very probably not an interspecific hybrid. A review of the history of *flavicarpa* points to a more probable origin as a mutation of *P. edulis*. There are several notable differences between typical *edulis* and form *flavicarpa*, however, including a high degree of cross incompatibility The two forms of the species deserve more study from the standpoints of both cytology and genetics.

FIG. 3. Meiotic metaphase I in *P. edulis* form *flavicarpa* showing 9 bivalent chromosomes.

No flowering material of *P. Pfordti, P. maliformis* × *laurifolia,* × *P. caerulea,* or *P. princeps-coccinea* could be obtained by the writer for studies of chromosome behavior at meiosis in these interspecific hybrids. All four appear to be completely sterile.

P. suberosa is the sole representative of the 2n = 24 group. Microsporogenesis is normal in the species, but there is evidence of strong secondary association between the bivalents at the first metaphase (Fig. 4). Secondary association in meiosis has been regarded as indicative of an earlier polyploidal origin (Darlington 1932: 219–223).

FIG. 4. Meiotic metaphase I in *P. suberosa* showing 12 bivalent chromosomes. Broken lines indicate pairs of bivalents in secondary association.

P. suberosa is also the sole representative of the 2n = 36 group. This 36-membered form is undoubtedly an autotriploid derivative of the 24-membered form, constituting a separate chromosomal race within the species. There are no conspicuous morphological differences between the two forms. The only distinguishable differences are to be found in the slightly larger leaves and a slight intensification of anthocyanin pigmentation in the young stems and on the dorsal surfaces of the sepals of the flowers of the triploid form. The species, however, is highly polymorphic, with all degrees of intergradation among its numerous variants, so that even these differences are not entirely reliable as a means of distinguishing the two races in nature. The triploid race appeared spontaneously among wild populations of the diploid race, the first collection being made in 1937. It produces fertile seeds, and has continued to reproduce and spread under natural conditions. Examinations of all herbarium sheets of collections made prior to 1937 in the Bernice P. Bishop Museum at Honolulu reveal none which might conceivably be the triploid form.

Contrary to what might be expected of an autotriploid, triploid *P. suberosa* goes through microsporogenesis with a fairly high degree of regularity and produces a preponderance of normal quartets of microspores. Megasporogenesis must be equally little disturbed, for the fruit produces a complement of seeds more or less comparable to that produced by the diploid. Multivalent chromosome configurations were observed in a few microsporocytes, indicating that there is some disturbance to normal bivalent pairing. In an occasional sporocyte, all orders of association from univalence to sexivalence have been observed. Anaphasic separation into equal

numbers appears to be effected rather uniformly despite multivalence, however, for daughter nuclei were rarely seen to contain more than, or fewer than, 18 chromosomes. There are extremely few abnormal microspore quartets, and correspondingly few abortive pollen grains.

DISCUSSION

Darlington and Janaki Ammal (1945: 114) give $x = 9$ as the basic chromosome number of the genus *Passiflora.* This number was doubtless assumed on the basis of 6 species with $2n = 18$ and one species which was reported as "$2n = 84$?." Determination of $n = 6$ for *P. pulchella* indicates that not 9 but a lower number probably is basic in the genus. With the exception of the aberrant species *P. foetida* ($2n = 20$), all of the species examined, including *P. lutea* ($2n = 84$?), comprise a polyploid series of which the monoploid number is 6. It is recognized that the total of 29 species and variant forms for which chromosome numbers are known or presumed is but a meager sample from a genus with over 400 known species, so it seems not unreasonable to suppose that other numbers, both euploid and aneuploid, may exist among species unreported here.

It is perhaps significant from the breeders' standpoint that all of the horticultural forms studied occur in the $2n = 18$ group. These forms exhibit a fairly high degree of interspecific compatibility, as evidenced by the numerous hybrids recorded (Bailey, 1935: 2487); but the hybrids themselves are almost invariably sterile. Their compatibility suggests closeness in relationship and, possibly, a common origin.

With an assumed basic number of $x = 6$ for the genus, the species in the $2n = 18$ group must be regarded as triploids. Triploidy, however, is generally considered to be a hindrance to the origin of fertile species because of the high order of meiotic irregularity which it induces. It seems unlikely, therefore, that the majority of species examined, all of which are fertile, have originated through triploidy. An assumed basic number of $x = 3$ would afford a number of more nearly reasonable explanations of the origin of $2n = 18$ species. These species could then be regarded as hexaploids of more or less ancient origin. As has occurred in many polyploid species of plants, cytological evidence of genomic composition has disappeared in the course of speciation and stabilization except in chromosome numbers.

How speciation within a group could occur is illustrated by the mutation from *P. edulis* to the form *flavicarpa.* The nature of the mutation has not been studied, but when it occurred it must have been drastic. The form differs from the species in several foliar and stem characters. The fruit is yellow instead of purple, and the seeds are brown instead of black. In addition, the flowering habit has been modified from strictly diurnal to partly nocturnal, and a barrier of almost complete incompatibility seems to have arisen between the mutant form and the species from which it is presumed to be derived. As mentioned earlier, the hybrid origin which was suspected by Pope (1935: 11) is not borne out by cytological studies.

P. foetida ($2n = 20$) and its varieties make up a group divergent from the euploid series to which all other species examined belong. Cytological studies to date have provided no clue to its probable origin. The possibilities exist either that it arose as a secondary polyploid from a $2n = 18$ species or that it belongs to a second euploid series, perhaps with a monoploid number of 5, for which additional species have yet to be discovered. If the plants growing in Hawaii are truly representative of the species, Janaki Ammal's (loc. cit.) determination of $2n = 18$ as the chromosome number must be considered to be in error.

As noted earlier, strong secondary association in *P. suberosa* ($2n = 24$) is taken as indicative of its polyploidal origin. The 36-membered form undoubtedly originated fairly recently as an autotriploid as shown by the absence of marked morphological differences in plant characters. It is supposed that triploidy resulted in the species through the mating of an unreduced gamete with a normal, reduced gamete. How the unreduced gametes might have been produced is suggested by the case of syndiploidy observed in an anther of *P. subpeltata.*

The occasional occurrence of all degrees of multivalence up to and including sexivalence lends credence to the supposition that the $2n = 24$ form is itself polyploid, at least tetraploid if not of a higher order of polyploidy, and that the derived form is at least hexaploid. The presence of 6 genomes, although bringing about some slight degree of irregularity in meiosis, allows for more or less normal anaphasic separation into two gametic 18-chromosome complements.

CONCLUSION

The study has shown that the basic chromosome number for the genus is at most $x = 6$, and may possibly be $x = 3$, rather than $x = 9$ as indicated by Darlington and Janaki Ammal (1945: 114). It has also called attention to the discrepancy in chromosome number determinations for *P. foetida.* It is thought by the writer that the aneuploid number of *P. foetida* presages the existence of another euploid series in the genus. The determinations made bring to 29 the number of species and variant forms for which chromosome numbers are known or may be assumed from the composition of various hybrids.

It seems highly probable that there may exist chromosome numbers other than those reported here among the 300-odd species of *Passiflora* which have not been examined. Studies of a greater number of species more fully representing the recognized taxonomic groups and of additional interspecific hybrid material would aid considerably in determining origins and relationships within the genus.

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Observations on the Heart Shell, *Corculum cardissa* (L.), and Its Associated Zooxanthellae

SIRO KAWAGUTI[1]

INTRODUCTION

THE HEART SHELL, *Corculum cardissa* (L.), has a peculiar type of shell. It is greatly compressed antero-posteriorly, resulting in a distinct heart shape, which is the source of the common name. Moreover, it has many zooxanthellae in its gill filaments, labial palps, mantles, and liver. The peculiar shape and habits of this mollusk may be explained by this association with zooxanthellae.

This is the second case of association with zooxanthellae known in the lamellibranchs. It is interesting to compare it with the other Tridacnidae, which is fully described by Yonge (Rept. Great Barrier Reef Expedition 1928–1929. 1: 283–321, 1936).

These observations and experiments were carried out at the laboratory of the Palao Tropical Biological Station and the reef flat in its vicinity in 1936 and 1940. A preliminary report was published in 1941 in *Science of the South Sea (Kagaku Nanyo)* 3: 179–180 [in Japanese].

HABITAT

At Palao *Corculum* is found on reef flats under strong sunshine. It usually lies on the sand flat where dead shells and coral fragments have accumulated, and its anterior end faces the ground. It lies in a roughly horizontal position, excavating the bottom to the form of its shell, which is sometimes greatly produced anteriorly, as is shown in Figures 2 and 3. There is usually no attachment to the bottom but exceptionally there are several short threads of byssus.

It is very difficult to find the shell in its habitat, as the upper surface is frequently covered with filamentous algae or muddy depositions. In an active state the shell opens by 2–3 mm. at the ventral end and a vigorous current is produced from an exhalant siphon which is projected slightly at the middle of the shell. An inhalant siphon is situated ventrally and on the same level of the shell. At the ventral end of the shell the mantle is separated. Very thin, small papillae appear at the distal portion.

THE SHELL

One specimen of shell is seen in Figures 1 and 2, from the top (or posterior in anatomical point of view) and left sides, respectively. The boundary of the shell rests, usually, on a plane but it is frequently slightly convex or concave. The height is not the same from

FIG. 1. Upper (posterior) surface of heart shell. (Natural size.)

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the mid-line to the posterior end as it is to the anterior end. The form of the shell is variable as is shown in Figure 3.

Side views of the shells usually display many similarities to those of *Cardium*. In some cases, however, the posterior surface is almost completely flat, with the posterior end of the shell indicated by a little projection and with somewhat of a depression at the mid-portion.

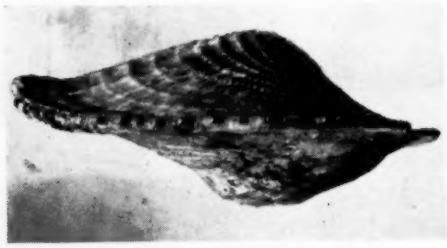

FIG. 2. Lateral view of heart shell. (Slightly reduced.)

It is frequently observed that a smaller shell has a rather elongate shape and a larger one has a more rounded shape. This relation may also be traced in one shell as is shown in Figure 4. When the shell outline is supposed as cut off at a certain growth line the remaining parts of the shell represent the form of the younger shell. In this manner, a series of shell forms is obtained such as is shown in Figure 4 *a-i*. These figures clearly show that the younger form is more elongate than the older one. This relationship is shown numerically in Table 1. The ratio of breadth (lateral width) to height (dorso-ventral) is greater in the larger specimens.

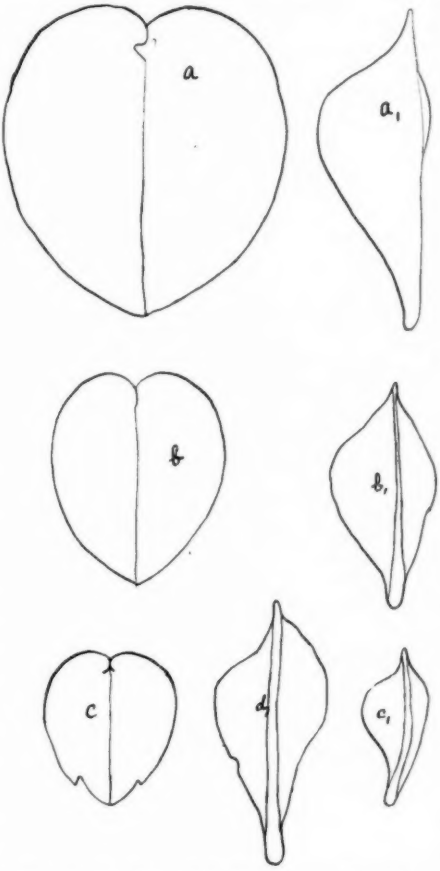

FIG. 3. Outlines of shells of *C. cardissa* showing variations in shape of shell. *a, b, c,* Posterior profile; a_1, b_1, c_1, d_1, lateral profile.

TABLE 1

MEASUREMENTS OF THE SHELL OF *Corculum cardissa*

LOCALITY	HEIGHT	BREADTH	LENGTH	THICKNESS	TOTAL WEIGHT	B/H*	S†	W/S‡
	cm.	*cm.*	*cm.*	*mm.*	*gm.*			
Palao	6.50	6.00	2.50	0.5-0.7	13.4	0.92	61.7	0.217
Palao	5.63	5.20	2.36	0.5-0.6	8.7	0.92	42	0.207
Ryukyu . . .	4.66	3.87	2.4	0.5	6.5	0.83	24	0.270
Ryukyu	3.25	2.85	1.45	0.2-0.3	1.99	0.88	14	0.14

* B/H Ratio of breadth to height.
† S Surface area in square centimeters.
‡ W/S Weight in grams per square centimeter of surface area.

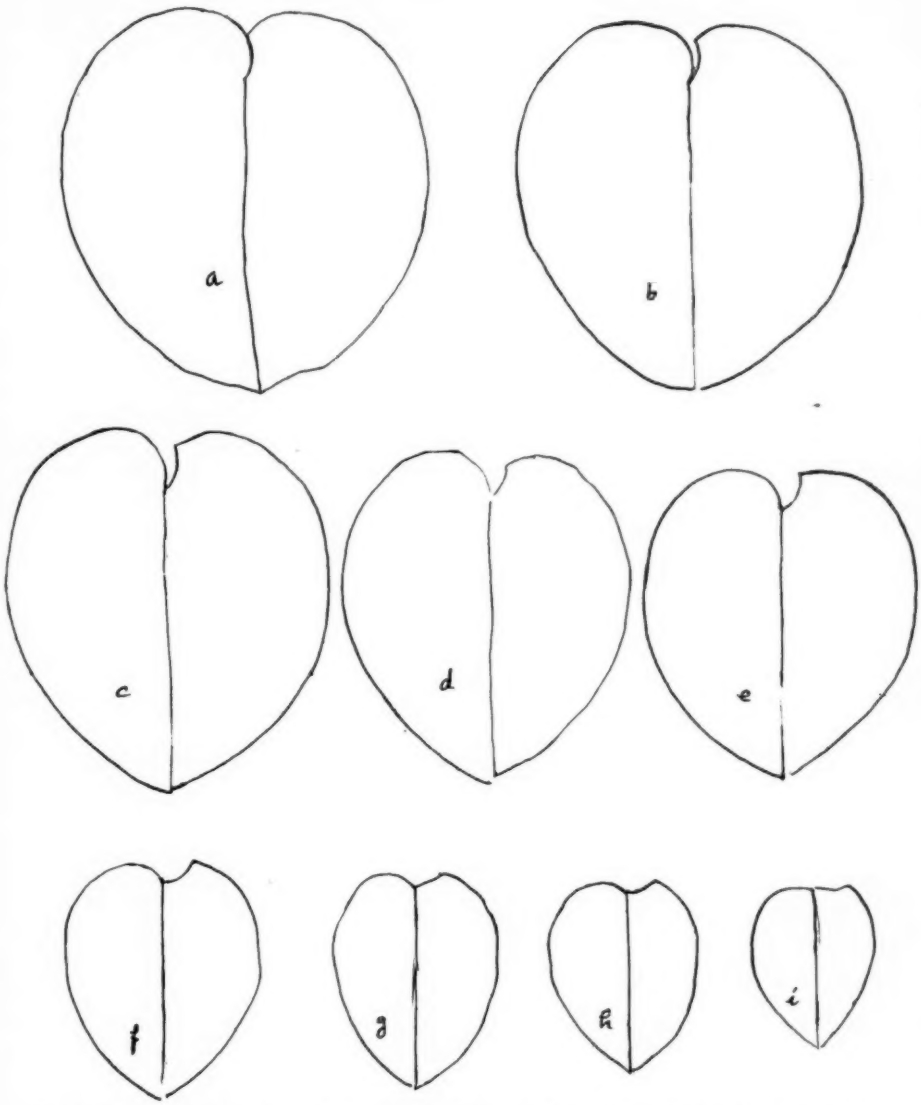

FIG. 4. Reconstruction of a series of growth forms of *C. cardissa.* (Explanation in text.)

The shell is remarkably thin, as is shown in Table 1. It is also remarkable in the uniformity of the thickness throughout the whole shell. Only at the anterior, that is, lower, side the ventral portion shows a slight thickening. In a very small specimen the shell is very thin but it rapidly attains a maximum thickness of between 0.5 and 0.7 mm. The area of cross section of shell is measured and weight of shell per unit of this area is cal-

culated in column 9. These data also bear out the same fact.

In a first glance at the shell, the lower side seems to be thicker than the upper side. But actually they are almost of the same thickness. This apparent difference is a result of the greater transparency of the upper side. On this side, there is a beautiful pattern which is shown in Figure 5. The pattern is formed by the mosaic arrangement of transparent mass and nontransparent whitish mass. On the lower side the transparent portions are scattered, rarely in rather large masses, and fade into whitish ground. Transparency of the shell is intensified if the shell is immersed in water because of elimination of reflected light from the uneven surface.

FIG. 5. Enlarged view of pattern on the shell of *Corculum*. The pattern is formed by the mosaic arrangement of transparent mass and nontransparent whitish mass.

LARVAL DEVELOPMENT

Corculum is a hermaphroditic animal. Development is indirect and it is remarkably rapid. Spawning was once observed on February 29, 1940, in the laboratory. A specimen collected on the previous day and cultured in a glass basin extruded eggs at 11 o'clock in the morning; by the end of 2 hours they had reached the two-cell stage. In the evening they had become veligers and began to move. The next morning, all of them had grown to the two-valved stage and were swimming at the surface of the culture medium. They grew into the usual type of bivalve shells by the next evening, and settled to the bottom. Up to this time, there was no indication of the heart shape which is characteristic of this animal. There are no zooxanthellae in any tissue at this time. In what stage they attain the association with zooxanthellae is not yet known.

ASSOCIATION WITH ZOOXANTHELLAE

Gills

The normal position of the internal organs is somewhat displaced in accordance with the deformation of the shells. The organs are shown in Figures 6*a* and 6*b*. The gills and mantles are the most interesting. The gills are situated at both sides dorsally. They are short and narrow in figures, even in the photograph in the living state (Fig. 6). In the active state, however, they expand fully, just under the mantle, almost filling the whole mantle cavity. The length of the gill filaments of the inner lamella is much greater than that of the outer lamella, especially at the middle portion. This serves to fill the mantle cavity with gill filaments in the active state.

The gill is dark brown in the living animal. When it is examined under a microscope many zooxanthellae are found to be present in the filaments (Fig. 7*a*). The zooxanthellae do not seem to be enclosed in the host's cells.

Mantle

The mantle shows similar modifications in its structure and relative position. It forms a thin and heart-shaped mantle cavity. The mantle edges are fused at the middle of the upper side into an exhalant siphon; more ventrally they form an inhalant siphon, in the

living state, without showing morphological fusion.

The mantle of the upper side is pale and contains only a few zooxanthellae. The lower side, however, is dark brown in color due to the presence of the great accumulation of zooxanthellae. The difference is most striking at the folding line of the mantle from upper to lower surfaces as is shown in Figure 7*b*. The lower side is almost solidly dark but the upper side is only scattered with the zooxanthellae.

FIG. 6. *a*, *C. cardissa* with shell removed. Seen from lower side. The many dark spots are colonies of zooxanthellae. (Natural size.) *b*, Body of *C. cardissa* as seen from upper side. (Natural size.)

The mantle is extremely delicate and thin except at the edge. These relations may allow effective penetration of light to the gill filaments where the zooxanthellae are accumulated in great abundance. On the lower side, however, there is no need for the light to penetrate through the mantle as there are no more zooxanthellae beneath the mantle.

There are many pigment granules on the outer surface of the mantle. They are blue, reddish-purple, or red in color, with significant fluorescence. They are a little larger than the dimensions of zooxanthellae. Whether these pigment granules may act as a filter for too strong light is not clear.

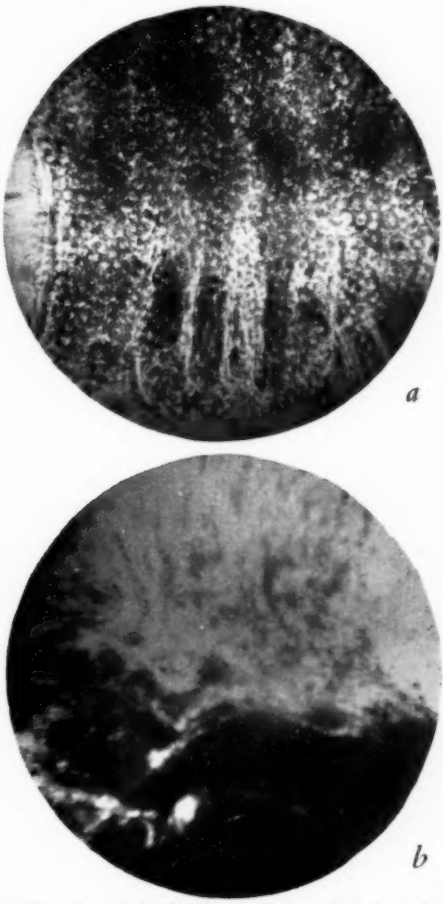

FIG. 7. *a*, Gill filaments of *Corculum* in living state, showing a full accumulation of zooxanthellae in them. A series of cilia is seen on each gill filament. *b*, A part of folding zone of mantle showing the great accumulation of zooxanthellae in the lower portion (seen evenly dark) and the lesser scattering in the upper portion.

Digestive organ

Many zooxanthellae occur in the lobes of the liver, as is shown in Figure 8. There are many grades of disintegration of zooxanthellae. From this fact one may conclude that the zooxanthellae are used as food although how they pass into the liver from gills or mantle is not clear.

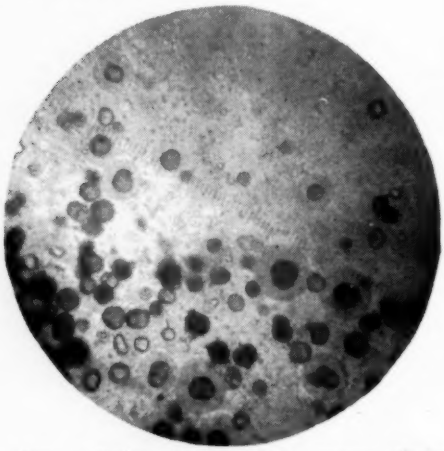

FIG. 8. Enlarged view of the content of the liver. There are many grades of disintegration of zooxanthellae in vesicles, probably phagocytic or digestive cells.

Oxygen consumption

In order to determine whether or not these symbiotic zooxanthellae have an effect on the physiology of *Corculum* the oxygen consumption in the light and in total darkness was measured. Two animals weighing about 15 grams each were placed in glass jars of about 400 cc. capacity. These were immersed in sea water and sealed with stoppers without leaving any air bubbles in them. They were first kept in total darkness in a simple thermostat containing sea water. In the second experiment they were exposed to the sunshine in the same thermostat on the grass land of the laboratory.

Oxygen tensions of the medium were measured at the beginning and the end of the experiment by Winkler's method. An injection syringe of 5 cc. capacity was used for an analyzing vessel. Details of the results are given in Table 2.

There was marked increase of the oxygen tension in the light. These increases are certainly caused by the photosynthesis carried on by the zooxanthellae contained in the gills and mantles. The amount of increase is comparable with that shown by reef corals.

The oxygen consumption while the animals were in total darkness is in the usual range for mollusks.

COMPARISON WITH THE TRIDACNIDAE

It is very interesting to compare these observations with the data recorded for *Tridacna crocea*, in which even in the light no significant changes in oxygen exchange were observed (Yonge, loc. cit.) owing, probably, to the great bulk of tissues for the amount of zooxanthellae present.

This would indicate that there is no need of zooxanthellae for the oxygen requirements of the animal. Moreover there is a sufficient water current to remove excretory substances. One may conclude therefore that zooxanthellae may be used only for food.

TABLE 2

OXYGEN CONSUMPTION OF *Corculum* IN TOTAL DARKNESS AND IN SUNLIGHT AT 28.5°–31° C.

CONDITION	WEIGHT	DURATION OF EXPERIMENT	O_2 INITIAL	O_2 FINAL	TOTAL DIFFERENCE	DIFFERENCE PER HOUR PER GRAM
	gm.	*min.*	*cc.*	*cc.*	*cc.*	*cc.*
Dark . . .	15.8	70	4.02	3.13	— 0.35	— 0.019
Light . . .	15.8	40	3.90	4.84	0.37	0.035
Dark . . .	15.9	70	4.02	3.24	— 0.32	— 0.017
Light . . .	15.9	40	3.90	4.94	0.43	0.041

The Tridacnidae have thick, heavy shells and usually rest on the hinge and umbo. Moreover, they culture immense numbers of zooxanthellae in the mantle edge which is exposed to the sunlight. Consequently the relation of the mantle and shell to the other organs is greatly different from in *Corculum*. The Tridacnidae may be divided into two groups according to their mode of life; one is a surface living species and the other a boring species. However, they both can attain immense size of shell in tropical seas where nutritive plankton is rather rare.

Yonge (loc. cit.) considered that the presence of associated algae may enable the Tridacnidae to exceed the limits normally set to the size of a plankton-feeder and thus be responsible for the immense size attained by *T. derasa*.

It would seem then that the presence of associated algae induces the immense size of shell in *Tridacna* but results in the thin and rather transparent shell of *Corculum*. However, the presence of the algae may not be the primary factor in the formation of the large shell in *Tridacna*, but it may have served to allow the greater development of an evolutionary tendency. That is, in the Tridacnidae it perhaps accelerated a tendency to settling into the reef with a heavy shell, whereas in *Corculum* it would seem to have accelerated a tendency toward expansion of a thin transparent shell.

Annual March of Daily Mean Temperatures at Honolulu

HAROLD S. PALMER[1]

THE PRESENT PAPER attempts to answer objectively the recurring question as to when the warmest and coldest weather occurs at Honolulu. For basic data the "daily mean temperature," which is the arithmetic mean between the maximum and minimum temperatures recorded during the 24-hour day, was chosen. It is usually reported to the nearest whole degree, since the temperatures used for its computation are not reported in fractions of a degree. If the arithmetic mean ends in five-tenths of a degree, it is arbitrarily rounded to the nearest even degree, whether this involves rounding up or rounding down.

In 1931, Mr. John F. Voorhees, then meteorologist of the Honolulu office of the U. S. Weather Bureau, supplied me with averages of the daily mean temperatures for each of the 365 days of the year. These covered the 41-year period from 1890 to 1930, inclusive. I do not know where the instruments were located from 1890 through 1904. From 1905 to 1922 the records were made on the Young Hotel Building, 121 feet above the ground, and since 1922 on the Federal Building, 99 feet above the ground. The difference in stations is not significant for the present study since it compares the averages for each date of the year and does not compare data from earlier and later periods. Leap day has been omitted from consideration.

Mr. Harry T. Tanaka, a student at the University of Hawaii, working on N. Y. A. funds, tabulated the daily means for the 10-year period from 1931 through 1940, and I have added the data for the 7 years from 1941 through 1947, thus getting the average daily mean temperatures for each of the 365 dates for the 58-year period from 1890 through 1947. The averages were calculated to tenths of a degree and are given in Table 1 and are shown graphically in Figure 1.

A study of the data for the 53-year period from 1890 to 1942 was reported to the Hawaiian Academy of Science in 1943 (Palmer, Harold S., The Annual March of Daily Mean Temperature at Honolulu. [Abstract.] *Hawaii. Acad. Sci., Proc.* 1945: 3). For that study a number of ways of smoothing and otherwise treating the raw data were tried. The method finally chosen as most satisfactory was that of 7-day progressive means, and is used in the present study. The method is this: the values for seven consecutive days are added, the sum is divided by seven, and the quotient is used for the middle, or fourth, day of the seven. The resulting 7-day progressive means are given in Table 2 and are shown graphically in Figure 2.

THE COLDEST DATE

The data show that February 12, 13, and 14 have the lowest smoothed temperatures, namely 70.9° F. It is reasonable to suppose that February 13 is the coldest of the three, and this is confirmed by the fact that it is the coldest date among the unsmoothed data. Calculation of the smoothed values to hundredths of a degree further confirms this choice since the values for February 12, 13, and 14 are 70.92°, 70.91°, and 70.93°, respectively. It must be admitted that working to hundredths of a degree is unwarranted since the raw data were taken only to the nearest whole degree; but the calculation is given for what it may be worth.

A disagreement is found in the data for the 17-year period, 1931–1947, similarly

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Manuscript received May 27, 1949.

TABLE 1

FIFTY-EIGHT-YEAR DAILY MEAN TEMPERATURES. AVERAGED, BUT NOT SMOOTHED

DATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1	72.5	71.3	71.8	72.5	74.2	76.1	77.2	78.3	78.2	78.1	76.3	74.1
2	72.0	71.6	71.5	72.4	74.0	75.9	77.3	78.0	78.5	78.1	76.0	74.0
3	71.7	71.8	71.7	72.6	74.2	76.2	77.4	78.1	78.5	77.8	76.0	73.8
4	71.6	71.4	71.2	72.4	74.1	76.1	77.5	78.3	78.5	77.4	76.2	73.8
5	71.7	71.5	71.4	72.3	74.0	76.3	77.2	78.5	78.5	77.4	75.9	73.8
6	71.6	71.5	71.3	72.6	74.0	76.3	77.2	78.6	78.2	77.4	75.9	73.5
7	71.8	71.5	71.4	72.5	74.2	76.2	77.4	78.4	78.2	77.7	75.4	73.6
8	71.7	71.3	71.3	72.4	74.6	76.2	77.5	78.4	78.5	77.3	75.2	73.3
9	71.7	71.2	71.4	72.6	74.4	76.3	77.6	78.4	78.7	77.3	75.6	72.9
10	71.4	71.1	71.1	73.1	74.2	76.5	77.7	78.3	78.4	77.2	75.6	73.1
11	71.7	71.2	71.2	72.8	74.5	76.6	77.4	78.3	78.4	77.4	75.4	73.2
12	71.6	70.9	71.2	72.8	74.7	76.7	77.5	78.3	78.3	77.2	75.2	72.7
13	71.3	70.5*	71.2	73.1	74.4	76.7	77.5	78.5	78.0	77.1	75.2	72.3
14	71.2	70.7	71.6	73.4	74.9	76.9	77.6	78.3	78.1	77.0	74.8	72.8
15	71.0	70.8	71.5	73.2	75.0	76.6	77.8	78.3	78.3	77.4	74.5	72.9
16	71.0	71.1	71.8	73.4	74.9	76.7	77.8	78.5	78.2	77.4	74.7	73.0
17	71.1	71.3	71.6	73.4	75.2	77.0	78.0	78.4	78.3	77.1	74.6	72.5
18	71.7	71.5	72.0	73.6	75.2	76.9	78.0	78.5	78.2	76.9	75.0	72.7
19	71.7	71.4	72.0	73.4	75.3	76.9	78.0	78.8†	78.1	77.0	74.8	72.8
20	71.2	71.4	72.1	73.1	75.4	76.8	78.1	78.2	78.1	77.0	74.4	72.8
21	71.3	71.5	71.9	73.3	75.5	76.8	78.0	78.4	77.9	76.9	74.1	72.7
22	71.3	71.8	71.9	73.5	75.4	77.0	78.0	78.5	77.6	76.5	74.2	72.6
23	71.6	71.6	72.1	73.3	75.5	77.0	78.0	78.5	78.0	76.5	73.8	72.7
24	71.3	71.9	72.2	73.6	75.5	77.2	78.0	78.5	78.1	76.5	73.8	72.5
25	71.2	71.9	71.9	73.8	75.7	77.1	78.1	78.4	78.3	76.5	74.0	72.2
26	70.9	71.5	71.8	73.9	75.5	77.2	78.1	78.4	78.1	76.5	73.6	72.4
27	71.1	71.4	71.6	74.0	75.6	77.3	78.2	78.4	77.9	76.7	74.2	72.4
28	71.1	71.1	71.7	74.0	75.7	77.5	78.2	78.4	77.8	76.2	73.7	72.3
29	71.0	.....	72.2	73.7	75.8	77.2	78.2	78.3	78.1	76.2	73.8	72.5
30	71.3	.....	72.2	73.8	76.0	77.2	78.2	78.3	77.8	76.5	73.7	72.1
31	71.3	.....	72.1	.....	75.9	.....	78.1	78.4	.....	76.6	.....	72.3

*Coldest date. †Warmest date.

smoothed. The coldest dates in February for this period are the tenth, eleventh, and twelfth, with smoothed values of 71.6°, but there are colder dates in March, namely March 7 to 13, with smoothed temperatures of 71.5°, 71.4°, 71.3°, 71.3°, 71.4°, 71.4°, and 71.5°, respectively. The graph of the smoothed temperatures for the 58-year period (Figure 2) has a secondary trough from March 8 to 11, with 71.3° on the four days.

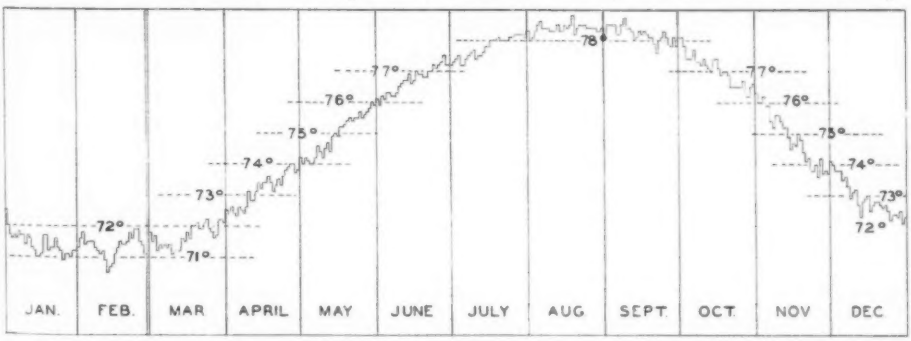

FIG. 1. Averages of daily mean temperature at Honolulu; not smoothed; 58 years, 1890 to 1947.

A POSSIBLE RHYTHM

From about January 10 to March 20 there are several fluctuations with ranges of about 0.6°. For most regions 0.6° would not be significant, but it might be significant for Honolulu where the conventional "mean annual range of temperature" is only 6.8° (78.3° — 71.5°) and the extreme range is only 38° (90° — 52°). Therefore a study was undertaken of the fluctuations in the first 3 months of each of the 18 years from 1931 to 1948. The value of 0.6° is about 9 per cent of the 6.8° mean annual range and is about 1.6 per cent of the extreme range. Inspection of Figure 2 shows troughs with center dates of Jaunary 16, January 28, February 13, and March 8 or 9. Eighteen sets of 7-day progressive means were computed for the first 3 months, one set for each of the 18 years. These means were plotted as 18 graphs, and were inspected to see to what extent there were troughs that coincided with one another and with the troughs of Figure 2.

In Figure 2 there are four more or less definite troughs and four or five more or less definite crests between January 1 and March 31. The 18 graphs for the 18 years show from three to six troughs and from two to six crests, their distribution being shown in the following tabulation.

Frequency of Numbers of Troughs and Crests per Year

I	II	III
2	0	1
3	5	2
4	5	5
5	7	6
6	1	4

I. The number of troughs (or crests) per year.
II. The number of years with the number of troughs indicated in I.
III. The number of years with the number of crests indicated in I.

The frequencies shown in the tabulation differ so much from the numbers of troughs and crests in Figure 2 that they make untenable the idea that some meteorological rhythm causes the troughs and crests of Figure 2.

Moreover, if there were some rhythmic cause that repeated in a significant number of the 18 years, we ought to find recurrences of troughs and crests on or about the same dates. A table was prepared with (a) the 84 days for which 7-day progressive means were calculated and (b) the 18 years as arguments. Each trough or crest was entered in the body of the table at the proper date and year. Only a few dates gave more than 3 years with either troughs or crests. January 5 with four crests and February 21 with five crests were the highest, but neither of these dates is noteworthy in Figure 2. January 21 had four troughs but also had one contradictory crest, and is moreover close to a crest in Figure 2. February 16, which follows by 3 days the trough of Figure 2, had three crests in the 18 years. The data for January 21 and February 16 definitely contradict the hypothesis of a rhythmic control.

Smoothed averages for the 41-year and the 17-year periods showed no exact coincidences of troughs and crests with one another, nor with the 58-year graph of Figure 2. So we conclude that there is no evidence of an annually recurring, rhythmic cause to explain the troughs and crests of Figure 2. No doubt the troughs and crests of graphs for single years are due to the influence of fronts related to highs and lows that pass near enough to affect Honolulu's weather. There certainly is no mystic relationship to the winter solstice.

THE WARMEST DATE

Selection of a warmest date is less simple because the smoothed values form a sort of plateau of 36 days, including 30 dates of 78.4°, with 2 dates a tenth of a degree lower and 4 dates a tenth of a degree higher. Among the 7-day progressive means for the 58-year data, we find 78.5° on August 16, 19, 20, 21, and 22, with 78.4° on August 17 and 18. The 7-day progressive means were subjected to a second, similar smoothing, which gave a series of five dates, August 18 to 22, with 78.5°. The middle date is August 20, which may therefore be taken as the warmest date.

TABLE 2

ANNUAL MARCH OF DAILY MEAN TEMPERATURES AT HONOLULU, 58-YEAR DATA, 1890–1947. SMOOTHED AS 7-DAY PROGRESSIVE MEANS

DATE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1	72.1	71.4	71.5	72.3	74.0	76.0	77.3	78.2	78.4	77.9	76.3	73.8
2	72.0	.5	.4	.4	.0	.1	.3	.2	.4	.8	.2	.9
3	71.9	.5	.4	.4	.0	.1	.3	.3	.4	.7	.1	.8
4	.8	.5	.5	.5	.1	.2	.3	.3	.4	.7	76.0	.7
5	.7	.5	.4	.5	.2	.2	.4	.3	.4	.6	75.8	.7
6	.7	.5	4	.5	.2	.2	.4	.4	.4	.5	.7	.5
7	.6	.4	.3	.6	.2	.3	.4	.4	.4	.4	.7	.4
8	.7	.3	.3	.6	.3	.3	.4	.4	.4	.4	.6	.3
9	.6	.2	.3	.7	.4	.4	.5	.4	.4	.4	.5	.2
10	.6	.1	.3	.8	.4	.5	.5	.4	.4	.3	.4	73.0
11	.5	71.0	.3	72.9	.5	.6	.5	.4	.3	.2	.3	72.9
12	.4	70.9	.3	73.0	.6	.6	.6	.3	.3	.2	.2	.8
13	.3	.9	.4	.1	.7	.7	.6	.4	.2	.2	75.1	.9
14	.3	70.9	.4	.2	.8	.7	.7	.4	.2	.2	74.9	8
15	.3	71.0	.6	.3	74.9	.8	.7	.4	.2	.2	.9	.7
16	.3	.0	.7	.4	75.0	.8	.8	.5	.2	.1	.8	.7
17	.3	.2	.8	.4	.1	.8	77.9	.4	.2	.1	.7	.8
18	.3	.3	.8	.3	.2	.8	78.0	.4	.2	.1	.6	8
19	.3	.4	.9	.4	.3	.9	.0	.5	.1	77.0	.5	.7
20	.4	.5	71.9	.4	.4	.9	.0	.5	.0	76.8	.4	.7
21	.4	.6	72.0	.4	.4	76.9	.0	.5	.0	.8	.3	.7
22	.4	.6	.0	.4	.5	77.0	.0	.5	.0	.7	.2	.6
23	.3	.7	72.0	.5	.5	.0	.0	.4	.0	.6	.0	.6
24	.2	.7	71.9	.6	.5	.1	.1	.4	.0	.6	74.0	.5
25	.2	.6	.9	.7	.6	.2	.1	.4	0	.5	73.9	.4
26	.2	.6	.9	.8	.6	.2	.1	.4	.0	.4	.8	.4
27	.1	.6	.9	.8	.7	.2	.1	.4	.0	.4	.8	.3
28	.1	71.6	71.9	.9	.7	.2	.2	.4	.0	.5	.9	.3
29	.1	.....	72.0	73.9	.8	.3	.2	.3	78.0	.4	.9	.4
30	.2	.....	.1	74.0	.9	77.3	.2	.4	77.9	.4	73.9	.3
31	71.3	.....	72.2	.....	75.9	.....	78.2	78.4	.....	76.3	.....	72.2

In the unsmoothed data, August 19, with 78.8°, is the warmest.

If the raw data are smoothed to hundredths as 7-day progressive means, we get August 21, with 78.50°, as a trifle warmer than any other date.

Thus, the three methods give three successive dates, August 19, 20, and 21, from which we may choose August 20 as the warmest date.

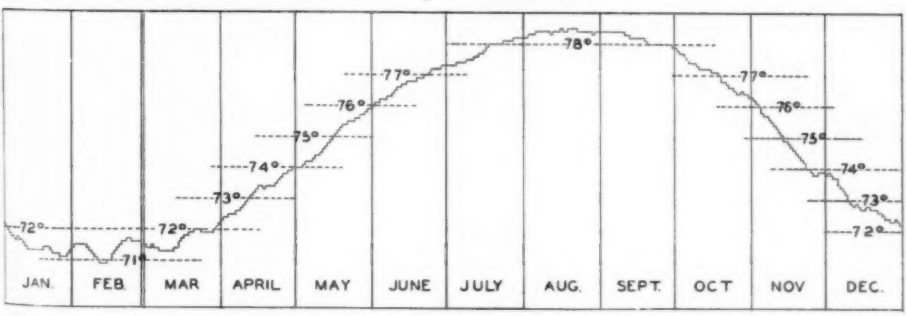

FIG. 2. Averages of daily mean temperature at Honolulu; smoothed as 7-day progressive means; 58 years, 1890 to 1947.

The 41-year data, reported on in 1943, smoothed to hundredths as 7-day progressive means, gave September 6, with 78.51°, as the warmest date. The 17-year data gave a run of 7 days with 78.6°, from August 16 through August 22. From these, August 19 may be taken as the warmest date, and agreeing well with the August 20 date from the 58-year graph.

The 36-day long "plateau" of Figure 2 was subjected to further study by means of 18 graphs of 7-day progressive means, from July 15 through September 25, for the 18 years from 1931 through 1948. On these graphs there were found a total of 43 dates which either had the maximum temperature for the year in question or were tied for the maximum. They ranged from as early as July 22 to as late as September 25, a range of 65 days. The mean and median dates were both August 23. The standard deviation was 14.5 days, a large value that implies uncertainty as to the date of the mean. Inspection of the 18 graphs showed a great variation—some were relatively smooth and some rather "wavy"; some showed a single maximum and some showed several scattered dates tying for the maximum; and, of course, the dates of the maxima varied greatly as described above.

The plateau of 36 days duration contrasts strongly with the wavy curve of the first months of the year. The difference is thought to be due to differences in the altitudes of the noon sun. In winter the altitude of the noon sun decreases steadily to a minimum about December 21 and then increases steadily. But in summer the noon sun on two occasions crosses the zenith of Honolulu, in 21° 18′ N. Lat. The noon sun is nearest the zenith about May 26 and again about July 16. On about June 21 the noon sun is 2° 9′ north of the zenith, and it is the same amount south of the zenith about May 16 and July 26. Thus for the period of 71 days between these two dates the noon sun is very high. During this time, also, the length of the daylight day varies only 17 minutes—that is, from 13 hours and 9 minutes to 13 hours and 26 minutes. Thus there is a long period in which the insolation is not only strong but is very uniform, which uniformity may well explain the plateau or long sequence of days of uniformly high average temperatures.

LAGS

If we select February 13 as the coldest date, we find that it falls 54 days after the winter solstice. Similarly, August 20 falls 60 days after the summer solstice. These dates divide the year into somewhat unequal parts. It takes 188 days to warm up from the coldest to the warmest date, but only 177 days to cool down again.

The most rapid cooling is from November 1 to November 26, during which time the 7-day progressive means drop 2.5°, from 76.3° to 73.8°, or at a rather steady rate of a tenth of a degree per day.

A longer period of fairly steady warming up extends from March 28 to June 15, with a rise of 4.8°, from 72.0° to 76.8°, in 78 days, or at a rate of about 0.06° per day. This period of rising temperature is not as steady or as rapid as the drop in November, but a short period of 10 days, from May 10 to May 20, gives a steady rise of about a tenth of a degree per day.

CONCLUSIONS

We have been considering only one element of the weather, namely the physical temperature, but the impression that the human animal gets of temperature is strongly modified by the effects of air movement and of humidity.

It appears that, on the average, the coldest date is February 13 and the warmest date is August 20. But, despite the alleged monotonous uniformity of Hawaiian weather, the dates of warmest and coldest temperature in any one year may come as much as a month earlier or later than the average dates. It also appears that the cold season may include several irregular fluctuations of temperature.

The Birds of Yap, Western Caroline Islands

HARVEY I. FISHER[1]

THE YAP GROUP of islands, which lies about 450 miles southwest of Guam and 125 miles northeast of the Palaus, is composed of four main islands: Rumung, Map, Gagil-Tomil, and Yap. There are several islets in the lagoon between Yap and Tomil islands.

The highest elevation (585 feet) is in the north-central part of Yap Island (Fig. 1). Except for this hilly area, the rest of Yap Island is below 200 feet. All of Gagil-Tomil is below the 200-foot elevation, and the highest parts of Map and Rumung are from 250 to 300 feet above sea level. The greatest length of the group is about 16 miles and the greatest width is 6.5 miles.

Ulithi atoll is the nearest land mass, lying about 90 miles to the northeast. To the southwest are the Palaus. Thus, Yap lies in a chain of islands from the Palaus in the south to the Marianas in the north. None of the islands in the chain is widely separated from the others. Furthermore, to the east is the whole group of Caroline Islands. Because these islands seem to form a perfect series of "stepping stones" for the movement of plants and animals from the southwest Pacific to the north Pacific through the Marianas and eastward through the Carolines to the central Pacific Ocean, it was deemed desirable to study birds of Yap, especially since the extensive work of the Whitney-South Seas Expeditions did not include Yap, and no modern collections of birds from this area are known.

Preliminary investigation and collections were made on Yap from July 28 to August 24, 1946. A total of 148 vertebrate specimens were taken: 17 amphibians, 28 reptiles, 9 mammals, and 94 birds. No attempt was made to collect large series of any species; rather an attempt was made to secure representatives of all species present. Records of the reptiles and amphibians taken have been published (Fisher, 1948).

The University of Hawaii sponsored this trip. I wish to acknowledge the aid of the United States Navy in furnishing transportation and other facilities. In particular, I wish to thank Captain O. M. Murphy, United States Navy Commander of the Yap Area, for use of various facilities at Yaptown and for his interest in the project. I also want to thank Mr. Eveni Levi of Tutuila, American Samoa, who accompanied me from Honolulu; he helped greatly in many ways. Dr. Ernst Mayr has checked the identification of all species discussed and has made critical taxonomic comments, many of which are included in the species accounts.

It is no longer possible for me to continue these studies. Hence, it seems worth while to put on record the observations of this brief survey.

As indicated above, the islands are relatively low. They are almost completely covered with vegetation. Yap and Rumung show a similar zonation of vegetation. On the inner side (toward the lagoon) these islands have extensive swampy areas, and mangroves of two kinds form dense thickets at the water's edge. On the outer side the islands have large areas of shallow water inside the coral reef. For the most part, these have coral and rock substrata with little mud. At the upper ends of the tidal swamps on the lagoon side are semi-open mudflats. Above these swamps or mudflats, or above the narrow beach on the sea side, the dense jungle starts immediately and continues upward to an

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elevation of about 200 to 250 feet on the southern end of Yap Island; on the northern end of Yap Island the hilly regions have dense stands of trees, but here and there are open areas of grassland with scattered *Pandanus* trees. Most of the rolling region to the south is this same type of savanna. The central part of Rumung is much the same.

Perhaps because of their lower elevation, Map and Gagil-Tomil islands do not have these open areas. The usual swamps and mangroves are present as a fringe about the circumference, but tall trees cover most of the rest of the surface.

In the discussion of the species, the habitats will be mentioned as mangroves, swamps, jungle, or savanna, referring to the various situations described above. An asterisk indicates that specimens were taken.

Puffinus pacificus, Wedge-tailed Shearwater.*—Five were observed flying over the south entrance to Tomil Harbor.

Puffinus l'herminieri, Dusky Shearwater.—Only one was seen, at the north end of Rumung Island.

Phaethon lepturus, White-tailed Tropic Bird.—Twos and singles were observed several times over Map Island.

Fregata ariel, Least Man-o'-War Bird.—Observed at close range at Yaptown (one bird) and at Balabat (three), August 6 and 13, respectively. Nine flew over Balabat on August 15. Natives reported that the species sometimes nested on Yap Island. The bird is closely associated with native traditions and customs, such as ceremonial dances, in which its feathers are used as ornaments. Identification was made of one roughed-out skin used as a headdress.

Sterna fuscata, Sooty Tern.—On July 30, six birds were resting on the beach at the north end of Rumung Island.

Sterna lunata, Gray-backed Tern.*—One collected from a flock of nine *Thalasseus bergii* off Orila, Map Island.

Thalasseus bergii, Crested Tern.*—Nine individuals were observed on tops of pilings of an abandoned fish trap off Orila, Map Island.

Gygis alba candida, Fairy Tern.*—This species was abundant on all the islands in those places where there were tall trees some distance apart. It was not seen in the deep jungle growth or in the savanna areas and was most frequently observed in the tall breadfruit, banyan, and coconut trees and in tall, isolated mangrove trees in the swamps. I did not find it in low shrubs such as are used by *G.a. rothschildi* in the western Hawaiian islands.

Also in contrast to *rothschildi, candida* was very noisy at night. This constant calling was observed on three occasions, at 9:00, 10:30 P.M., and 12:15 A.M.

The fairy tern, like the man-o'-war bird, is frequently used as an ornament of dress. Three natives had outlines of this tern tattooed on their shoulders.

Anous stolidus pileatus, Common Noddy.*—The noddy was found only on Tarang Island in Tomil Harbor. Here, an estimated 250 were seen, usually in the tops of pandanus, breadfruit, and chestnut trees. Old nests were found in the top whorls of pandanus trees, 12 to 18 feet from the ground. No nests were observed in higher or lower sites. Egg shells were found on the ground, indicating that nesting had occurred not long before. Some nests were apparently under construction, for they contained in their walls seaweed that was still green. Furthermore, two birds carrying strands of seaweed were observed flying into nests.

Pluvialis dominica fulva, Pacific Golden Plover.*—In late July an occasional single or pair was observed. By August 15, they were quite numerous, 15 to 25 birds in 150 yards of beach, along the beaches, tidal flats, and marshes, but they did not fly or feed in flocks. They were also abundant in open areas of savanna and around the Nif airfield.

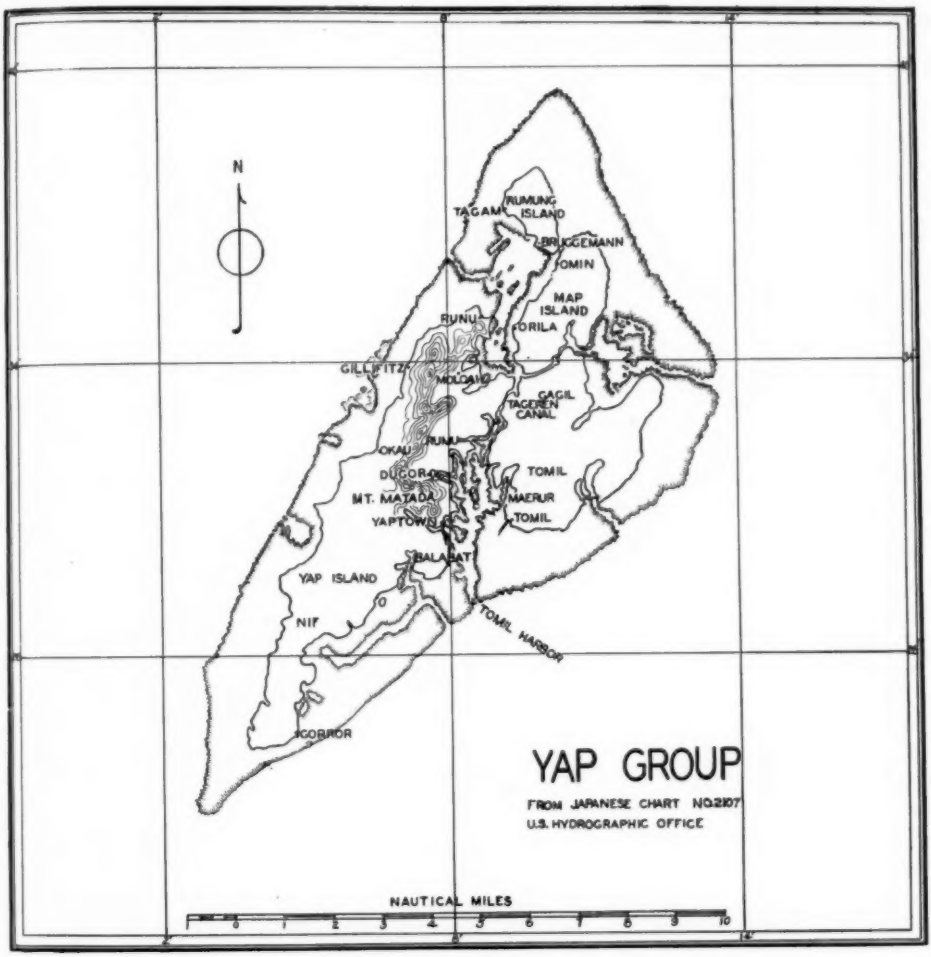

FIG. 1. The Yap Group of islands.

Charadrius mongolus, Mongolian Dotterel.*—One was collected on the mud of a small taro patch in the jungle ½ mile west of Balabat.

Numenius phaeopus variegatus, Whimbrel.*—Singles, pairs, and groups of three were commonly found on mudflats where there was no vegetation. Three were observed feeding on the grass-covered airstrip at Nif. No change in numbers was observed during our stay.

Numenius tahitiensis, Bristle-thighed Curlew.*—Only two singles were observed, both on rocky beaches.

Tringa glareola, Wood Sandpiper.*—One was collected on a mudflat at Moloai, Yap Island, August 10. No others were seen.

Heteroscelus incanus brevipes, Wandering Tatler.*—As would be expected, several individuals were seen on rocky stretches of beach, but they were just as numerous on small mudflats and around small patches of

FIG. 2. Dense jungle growth, 150 feet elevation, Dugor, Yap Island. Habitat of *Rhipidura, Monarcha,* and *Myzomela.*

taro in the dense jungle. One was observed in an open area of the savanna region.

Arenaria interpres, Turnstone.*—One flock of five and one flock of two were observed on Yap Island, August 6 and 16, respectively.

Crocethia alba, Sanderling.*—Occasional individuals were found along the beaches.

Demigretta sacra, Reef Heron.—Of 14 individuals observed on beaches and mudflats from July 28 to August 16, 11 were dark gray, one was light gray, and two were white in color.

Nycticorax caledonicus, Rufous Night Heron.—Two were in the edge of jungle adjoining the Nif airfield.

Ixobrychus sinensis, Chinese Least Bittern.*—These bitterns were most numerous around the water-filled bomb craters in the Nif airfield; on one occasion, 49 were seen in 4 hours. However, individuals were present around permanent and temporary rain-filled depressions in all parts of the islands. Each taro patch, no matter how small, had at least one bittern. They were abundant in the mangroves, in places a bird every 100 yards. Mayr (1945: 285) stated that this species was mostly nocturnal. I found it usually active in the daytime—feeding, calling, and flying about from one pond to another. Its call was not heard at night.

Anas (superciliosa?).—The "dark, female mallard with white line above its eye," observed by Levi and me probably was *superciliosa.* It was on the saltwater lagoon just off Yaptown. Captain O. M. Murphy said that the birds were frequently seen around the craters in the Nif airfield and that they were present throughout the year, but I did not find them there.

Gallus gallus, Domestic Chicken.—A few semi-domestic fowl were found in the jungle near the native villages. I was told that before the war such feral chickens nested in many different places. During the naval blockade in the latter part of the war the Japanese military forces hunted down most of them for use as food.

Poliolimnas cinereus collingwoodi, White-browed Rail.*—Mathews, in 1939, described the subspecies, *micronesiae,* and stated that Micronesian specimens were intermediate between *collingwoodi* from the Philippines and specimens from Vulcan Island. Examination of 32 specimens of *"micronesiae"* and a series of *collingwoodi* failed to substantiate his remarks. Mayr (in litt.) stated, "To this subspecies *(collingwoodi)* belong also the specimens from Talaut Islands, Palau, Guam, and Ruk. There are some characters peculiar to each locality but the differences between populations of these islands

FIG. 3. Grassy swamp, 20 feet elevation, Rumu, Yap Island. Habitat of *Poliolimnas cinereus.*

are not sufficiently constant and conspicuous to permit separation from *collingwoodi*."

These rails were present in all suitable taro patches or marshy areas that were investigated. They were not found in saltwater marshes but were present in marshes of brackish water less than 200 yards from the sea and only 2 to 5 feet above sea level. All areas found to be occupied by this species had three things in common: mudflats, shallow water (2 to 4 inches), and clumps of heavy marsh grasses.

Apparently the size of a taro patch has little to do with the number of rails present. I never found more than one pair in any isolated marsh or taro patch, and I investigated 13 such places, ranging in size from circular areas 50 feet in diameter to swamps containing 3 to 5 acres. A pair was collected from each of two smaller taro patches; during the following 3 weeks no rails were seen there, although the areas were visited every other day during that time. On two occasions individuals were flushed from dense grass some 50 yards from swampy areas. On both occasions the birds flew strongly and swiftly to cover in the swamp. I never saw this species more than 5 feet from heavy, grassy cover.

Two trips were made at night to areas in which rails fed in the daytime. In 4½ hours of observation no birds were seen and no calls were heard.

At Balabat, at 10:30 A. M., on August 11, I saw an adult run across a small opening in the middle of an abandoned taro patch overgrown with water grass. A few seconds later another adult followed; it was collected. When I retrieved the bird I found I had also collected a chick. At 2:30 P. M. on August 12 in a similar area, I watched two adults and a brood of four chicks feeding in water 1 inch deep. During the entire 40 minutes this group was watched, both adults kept their tails up in the air and jerked them vertically at 5-second intervals. They kept in a close

FIG. 4. Elevated trail in sea level swamp, Balabat, Yap Island. Habitat of *Ixobrychus* and *Poliolimnas*.

group, except for occasional straying by a chick; when a chick strayed the parent called, *k-uk, k-uk, k-uk,* in contrast to the usual, hard, *kuk, kuk, kuk.* So near to each other did these birds stay that I was able to collect all six with a single shot from a 410-gauge shotgun at a distance of about 25 yards.

The adults were a male and a female. The chicks were covered with black down. Their legs were dull blue. The distal third of both the upper and lower mandibles was dirty-ivory in color; the middle third, extending proximally to the middle of the external nares, was black. The basal third was washed-yellow. The call of these chicks, whose body length was 2 inches, was much like that of day-old domestic chickens, but finer, shrillet, and weaker.

Ducula oceanica monacha, Micronesian Pigeon.*—These were not numerous on the islands, but one could be certain of seeing five or six in a half-day. It was seldom seen in the savanna area, except at dusk when there was considerable movement between wooded regions. As a rule, the birds were first observed high in the barer branches of trees 30 to 60 feet in height, but one was collected while it rested on a nest some 20 feet from the ground in a breadfruit tree; the nest was old and empty. The call is a single *augh* or *ungh.*

FIG. 5. Typical taro patch swamp, Omin, Map Island. A pair of rails nested here.

Gallicolumba xanthonura, Ground Dove.*—Comparison of specimens from Yap and the Marianas revealed little significant difference. The only female from Yap was somewhat darker above and particularly darker below in the throat and breast; specimens from the Marianas are more rufous cinnamon in these parts of the body. Size seemed to be identical in the two series.

This species is uncommon on the island; I saw only 14 (singles, except for a male and a female collected together) in 4 weeks. It appeared to be limited to mangrove thickets in or near water and was not seen anywhere in the interior of Yap Island.

Rhipidura rufifrons versicolor, Rufous-fronted Fantail.*—Mayr (in litt.) wrote as follows:

The Yap race which I had not previously seen is more distinct from the races of the Marianas Islands than I had expected. The extensive, buffy, ochraceous wash of belly and flanks is missing. The well-defined, clear, white upper throat is another striking difference as are the gray-brown flanks. The upperparts are darker and more rufous with the contrast between rump and back much less pronounced. Actually, the Yap bird is, in the coloration of its underparts, much more similar to the Solomon Islands races and in particular to *brunnea* from Malaita Island. It differs from that race by the more extensive white tips on the tail feathers and broader white edges on the feathers of the breast and middle of the abdomen. The rufous zone on the lower back is more reduced. There is a more distinct grayish wash in the black portions of the tail feathers. The similarity is so striking that I wouldn't be surprised if Yap had actually been colonized from Malaita.

Although found on all the islands, they are most abundant on Tomil. The edges of low undergrowth in lowland jungles and the edges of mangrove swamps seemed to be favorite habitats, but a few were seen far back in the jungle. Without exception, the birds were found in twos or in family groups; three broods of nearly fledged young (three in each brood) were following pairs on August 11.

They are constantly on the move and are wary, but they, at this season at least, came in toward squeaking noises. They responded best to the sound of two pieces of seasoned wood being knocked together, as when ashes from a pipe were knocked out by hitting it against a gunstock. As one moved along a trail these birds frequently flew out ahead, displaying vigorously. They became most active just after sundown and before total darkness.

Monarcha godeffroyi, Monarch Flycatcher.*—Specimens collected showed much individual variation in extent of the black, brown, and white coloration. Two birds in brown coloration, similar to *M. takatsukae* from Tinian, were taken. Both were adult females, on the basis of degree of ossification of the skull and development of the ovaries; one was feeding nearly grown young. Immatures collected were dirty-black or brownish-black with dirty-white markings. Males were white-backed with white ventra, and the females had a white ring of varying extent about the neck.

On all islands of Yap, the species was abundant along the trails in heavy jungle. In this habitat the species was usually found 20 or more feet up in the vegetation, not in

FIG. 6. Sea level swamp, Balabat, Yap Island. Habitat of *Poliolimnas* and *Ixobrychus;* in surrounding mangroves *Gallicolumba xanthonura* was collected.

the low understory as was *Rhipidura.* However, this flycatcher was also observed perched on bare pandanus limbs (10 to 20 feet high) in the savanna region; here, it flew out after insects in typical flycatcher fashion. Mayr (1945: 92) noted that this seldom occurred in *Monarcha*; he also stated that the tail drooped vertically as the bird perched motionless. The tail was never drooped in the monarchs of Yap.

Aplonis opacus kurodai, Micronesian Starling.*—Three specimens from Yap agree fairly well with *orii* Takatsukasa and Yamashina from the Palaus, but the gloss on the birds from Yap seems to be more blue green, less bottle green; this may be due to slightly greater wear on the specimens from the Palaus. The bill seems slightly longer on the birds from Yap (Mayr, in litt.).

The species was abundant on all the islands in all types of cover except the savanna. Birds were most numerous, however, in the tops of high trees and were seldom, if ever, encountered in low, dense brush. The tops of coconut trees were much used as singing perches, and hau trees *(Hibiscus tiliaceus)* were frequented for their fruits. No nesting birds were found, but one juvenile was observed (August 7) begging and receiving food, and an adult was observed carrying food on August 16. As in other places, this species is in frequent conflict with other species; on Yap, *Myzomela cardinalis* and *Monarcha* were the chief victims of this conflict.

Myzomela cardinalis kurodai, Cardinal Honey-eater.*—It is unfortunate that the series of skins from Yap contained only one of a female, for the races are more clearly pronounced in the females. The one female agrees closely with an adult female *kobayashi* from Palau; both have distinct olive edges to the tail feathers, and the red is restricted to the top of the crown and does not extend to the nape; the comparative blackness of the scapulars in the Yap bird is perhaps due to its fresh plumage. The only difference between these two females is that the red of the crown and throat of the specimen from Yap is more cherry red, less scarlet, and there is a more pronounced zone without red between the upper throat and breast and between the crown and back. The wing and tail of the Yap race appear to be somewhat longer. The bill of the Yap birds appears to be longer than that of the Palau birds, but measurements do not confirm this visual impression. The edge of the newly molted primaries seems more olivaceous in Palauan than in Yap males. The under-tail coverts of birds from Yap seem blacker than in birds from Palau. On the basis of the specimens before me I would not be inclined to recognize *kurodai,* but it must be considered that the Yap series is in full molt. (Mayr, in litt.)

The honey-eaters were present in all suitable habitat on all islands. They were most abundant in low brush, no matter whether this brush was in the jungle, in otherwise open country, or in a mangrove swamp. In their brush habitat the birds appeared to be weak flyers, their fluttery flights seldom longer than 15 feet, but on August 21 one was observed over the center of Tomil Harbor, more than ½ nautical mile from land.

As a rule, they were observed in pairs, but on August 7 a brood of three was following

a pair. On August 10, a female (collected) was starting a nest in the outer tips of a branch some 10 feet from the ground. Another female (collected, but unfit for a specimen) was observed carrying food on August 10.

Zosterops conspicillata hypolais, Bridled White-eye.*—The Yap subspecies, *hypolais,* is strikingly different from all the other races of the species. It is by far the most grayish race of the species. The eye-ring is inconspicuous and the dark area under the eye is grayish rather than blackish. The white loral region is much reduced. The upperparts are gray, with a greenish tinge, most conspicuous on rump and crown. The underparts are somewhat like those of *rotensis* but slightly more yellowish, less buffy, particularly on the flanks. The size seems the same as in most other races of this species in which the wing varies between 55 and 58 millimeters in length in adult males. (Mayr, in litt.)

This species was usually confined to the undergrowth at the edge of the jungle. One could find it in numbers from 2 to 15 in almost every such area 100 yards long.

Rukia [Kubaryum] oleaginea, Large Yap White-eye.*—This species differs from the related *Zosterops conspicillata* by being larger, darker, and more brownish olive. "In general coloration it is remarkably similar to *sanfordi* from Ponape. It is somewhat darker, particularly on the crown, forehead, and lores. There is an extensive blackish zone in the malar region and under the eyes, which is barely indicated in *sanfordi.* The underparts also are darker and more grayish, while in *sanfordi* they are more brightly greenish buff. Rump and tail, as well as the edges of the primaries and secondaries, are duller. The legs are duller, more grayish horn color rather than yellow as in *sanfordi.* The two principal differences between the two species are, however, in the shape of the bill, which is nearly twice as long as in *sanfordi,* and in the eye-ring which is obsolete in *sanfordi.* The exposed culmen measures about 14 millimeters in *oleaginea* and over 20 in *sanfordi.*" (Mayr, in litt.)

In the month spent on Yap, only two individuals were observed; one on August 6, 1 mile northwest of Yaptown, Yap Island, and one on August 7, less than ¼ mile from the same area. One was in a bush overhanging a swamp in dense jungle, and the other was in low, thick underbrush 200 yards from a swamp.

Lonchura punctulata, Weaver-Finch.*—The three skins agree best with a series of the race *cabanisi* from the Philippines. They are also rather similar to the race *topela* from the Asiatic mainland but are distinguished from this subspecies by the fine barring on their flanks and by a less extensive brown area on the throat. (Mayr, in litt.)

This weaver-finch was found in all open and grassland areas on the islands. Flocks of 40 were observed in the shorter, dry grass of the savanna regions, and they were especially numerous in flocks of 5 to 20 birds along grassy roads and wide trails where they were feeding on seeds. Some immatures were begging for and receiving food on August 16.

This species probably was introduced on Yap.

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The Marine Algal Communities of Stanmore Bay, New Zealand (Studies in Inter-tidal Zonation 1.)

V. J. CHAPMAN[1]

INTRODUCTION

THE MAIN PURPOSE of the present and subsequent studies is to obtain a picture of the algal vegetation on different types of shores in the Auckland province, and to correlate, if possible, the observed zonation with the principal features of the tidal factor. A broad general picture is the aim, and it is not expected that all areas will be studied intensively. Factors other than tidal factors will clearly be involved, but since air exposure (and this includes water loss, exposure to high temperatures, exposure to salinity changes) is a causal factor and is primarily due to tidal phenomena it has been selected for primary investigation. Information is also required as to the number and location of critical levels on the different types of shore, and this is a further aspect that will be investigated.

GEOLOGY

The present study concerns Stanmore Bay, which lies between Red Beach and Manly on the north coast of the Whangaparoa Peninsula at its proximal end. It is about 25 miles north of Auckland and is just within the Hauraki Gulf (Fig. 1). The sea-water is considerably purer than that on the south side of the peninsula where there is sewage and harbour contamination.

The bay is backed by high cliffs which in the centre terminate in a narrow sand-dune shelf, but which at both ends come down sheer to the sea. The rock is the soft Waitemata sandstone and erosion is progressing continually at the two ends of the bay. At the northern end there is an outcrop of Parnell Grit, which is more resistant to wave action. Here vertical rock faces and dissected platforms are to be found.

On either side of this promontory the soft rock has been worn down to beach level and is continually being covered and uncovered by the beach sand. Because of this the vegetation on this low beach shelf is restricted since sand scour eliminates all but the hardiest plants, especially from mid-tide upwards. Towards low water mark the rock is maintained free of sand and here there is a good covering of vegetation.

The above type of flat shelf is to be found on both sides of the bluff separating Stanmore from the small bay immediately to the northwest, but the latter differs from Stanmore in that there are some big boulders near high water mark. The northwestern end of the small bay terminates in a steep bluff with a wide wave-cut platform and a large cave at the base.

AREA

The area studied included the flat beach shelf in the centre and northwest of Stanmore Bay, the northwest bluff, and the whole of the small bay to the northwest leading up to Red Beach. The cave in the second bluff did not form a part of this investigation.

THE FAUNA AND FLORA

On the sea shore, especially on rocky coasts, it is impossible to consider the plants and animals independently. In this particular area the dominant animals have been included but secondary species have been neglected. The communities recognised belong to four

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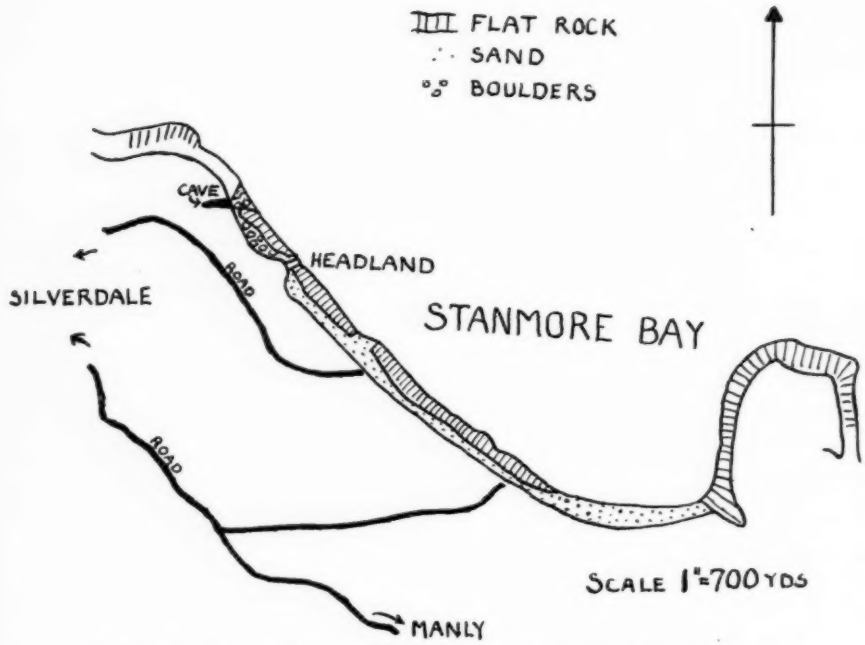

FIG. 1. Sketch map of part of the Wangaparoa Peninsula at the proximal end.

major formations which, as Stephenson (1939) suggests, have a very wide distribution. These four major formations are:

A. Littorina formation of the upper littoral.
B. Barnacle formation of the mid littoral.
C. Mixed algal formation of the lower littoral. This is a new nomenclature but the belt is to be found in many parts of the world. In Stephenson's work it would include part of the lower barnacle zone and part of the sublittoral fringe.
D. Sublittoral brown kelp formation (sublittoral fringe of Stephenson). It seems better to recognise at this level at least two formations, one dominated by large brown seaweeds (kelps) belonging to the Laminariales or Fucales, and one dominated by green, red, and brown algae. The former is to be found in colder waters and the latter in warmer waters where coral will grow.

The following is a description of the various zones as they occur at Stanmore (see Fig. 2).

Littorina Formation

1. **Melaraphe–Lichina association**

The dominant species are *Melaraphe oliveri* and *M. cincta,* which are closely allied to *Littorina,* and the maritime lichen *Lichina pygmaea.* The *Lichina* occurs in patches and there is no complete vegetation cover. A number of other species are to be found in the association. *Bostrychia arbuscula* occurs in the lower part of the zone; in the upper part a blackish belt of *Brachytrichia quoyi, Hydrocoleus lyngbyaceus,* and *Entophysalis granulosa* covers the rocks and boulders. Still higher on the boulders *Calothrix scopulorum* and *Entermorpha procera* f. *novae-zelandiae* are to be found. This association is not to

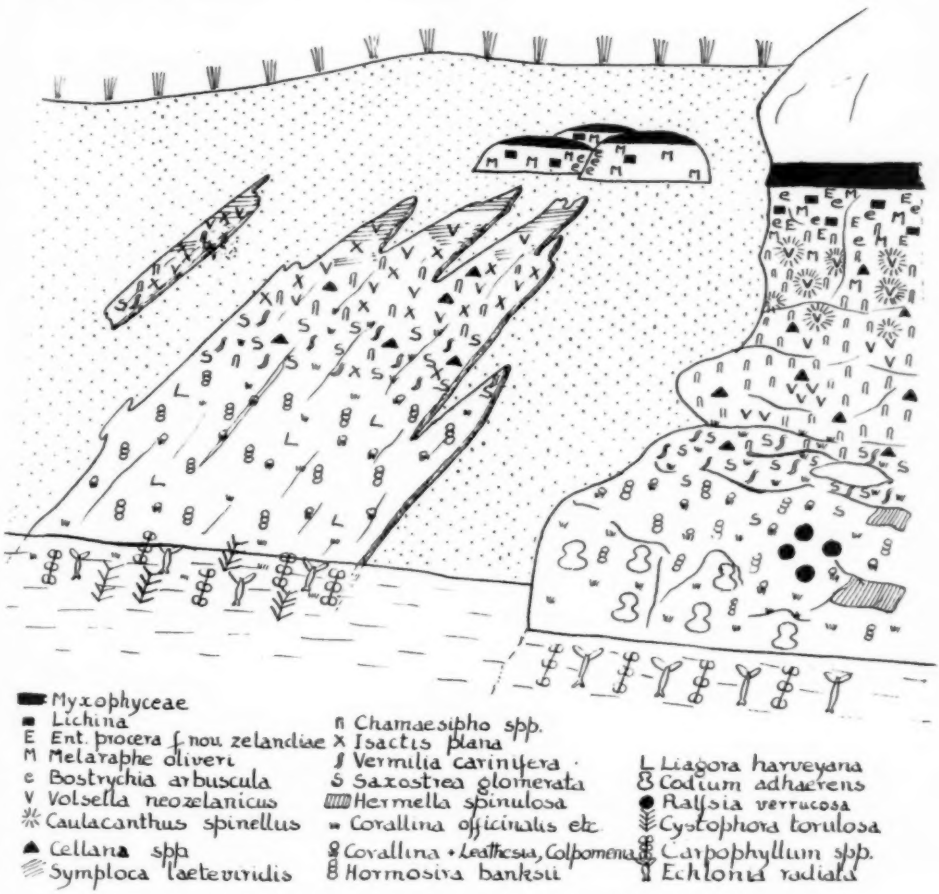

FIG. 2. Diagram of zonation on flat rock (left) and bluffs (right) at Stanmore Bay.

be found on the flat shelf of the beach as the shelf is usually covered by sand at the level at which it would occur. It is therefore restricted to the bluffs and to the large boulders in the small bay. The lower part of the zone is characterised by the presence of the two barnacles, *Chamaesipho brunnea* and *C. columna*, the latter being more abundant than the former.

Where the rock is overhanging, so that there is more shade and presumably less evaporation, one may find *Rhizoclonium tortuosum*, *Enteromorpha salina*, and *Wittrockiella* sp.[2] Here too may be found tufts of *Caulacanthus spinellus* and one or two outliers of *Volsella*, the mussel of the belt immediately below.

Barnacle Formation

2. **Chamaesipho–Volsella–(Apophloea) association**

In this area the dominants are *Chamaesipho columna* and *Volsella neozelanicus* but in other places it is evident that the red alga,

[2] This is a new species of an interesting genus. A description will be published separately.

Apophloea sinclairii, is normally co-dominant. The red alga is to be found in this belt at Stanmore, but not in abundance. In order areas also there is usually some development of *Chamaesipho brunnea* but the species is not common in this locality. The species of *Chamaesipho* extend rather higher than does the *Volsella*. The associated species vary with the physiography but among the mollusks one may find both species of limpet, *Cellana ornata* and *C. radians*. On the flat beach rock one finds black patches of *Isactis plana, Symploca laeteviridis, Microcoleus tenerrimus, Calothrix scopulorum*, and red patches of what appears to be *Hildenbrandtia* sp. *Corallina* occurs in shallow pools, though if the pools are sandy it is replaced by *Pylaiella (Bachelotia) novae-zelandiae* (Chapman and Ambler, in press). In places the *Isactis* and *Symploca* are sufficiently abundant to form a distinct fasciation: the former does not extend to quite the same height as the *Volsella*. *Symploca* tends to replace the other alga in this area.

At the bluffs, where there are vertical rock faces, other species are to be found. These include a more frequent appearance of the large barnacle *Elminius plicatus*, the limpets *Cellana ornata* and *C. radians*, and the following algae: *Caulacanthus spinellus, Gelidium pusillum G. caulacantheum, Bostrychia arbuscula, Rhizoclonium hookeri*, and *Polysiphonia rudis*. It is here also that occasional patches of *Apophloea* may be seen.

The *Caulacanthus* is interesting because each colony appears to have started within a group of mussels and to have radiated out from that centre, so that each group of mussels becomes surrounded by a ring of the algal felt.

3. Vermilia–Saxostrea association

Both the species *(Vermilia carinifera* and *Saxostrea glomerata)* occupy a well-marked zone. The rock oyster is rather more abundant than the serpulid worm and also extends to a higher level on the shore, so that it overlaps into the association described above. Likewise the *Vermilia* often descends somewhat lower on the shore than the oyster. An alternative treatment would be to separate these animals into two independent communities but in view of the overlap they are here retained as one association. This community is absent from the flat shelf and is only to be found on the more resistant rocks of the bluffs. The associated species are not numerous and include *Chamaesipho columna, Elminius plicatus, Caulacanthus spinellus, Gelidium pusillum, Peyssonelia* sp., *Corallina officinalis* (basal portion only), and *Lyngbya confervoides*.

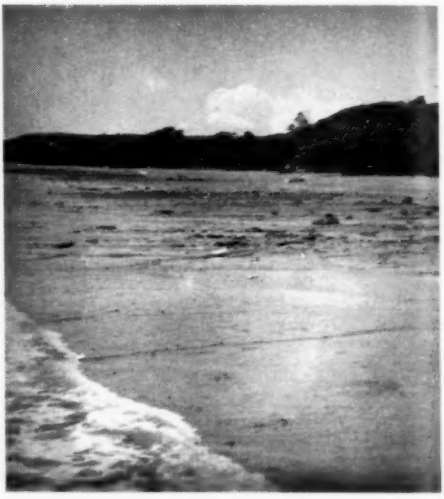

FIG. 3. The flat shelving beach at Stanmore Bay.

At the bluff the lower part of this zone is further characterised by a considerable local development of *Ralfsia verrucosa* and also of the worm *Hermella spinulosa*. Scattered through both the *Chamaesipho–Volsella* and *Vermilia–Saxostrea* associations one may find the mollusks *Lunella smaragda* and *Lepsiella scobina*.

Lower Littoral Mixed Algal Formation

4. **Hormosira–Corallina association**

This association is extremely well-marked both on the flat rock shelf and also on the more varied rock faces of the bluffs. *Hormosira, Corallina officinalis,* and *Codium adhaerens* are present at all seasons, but *Leathesia* and *Colpomenia* are mainly to be found in the summer months. *Corallina* extends up beyond the normal limit of this association, but only where there are cracks or shallow depressions that remain moist when the tide is below the upper limit of the association as a whole.

Since this association is near low water mark, conditions are favourable for a number of species and the flora is relatively rich. It also includes the serpulid *Vermilia* and *Hermella spinulosa.* The algal species are as follows:

Leathesia difformis (spring and summer) (ab.)
Colpomenia sinuosa (spring and summer) (ab.)
Microdictyon sp. (see footnote 2, p. 65.) (o.)
Laurencia thyrsifolia (f.)
Laurencia botryoclada (o.)
Laurencia pinnatifida (o.)
Caulacanthus spinellus (l.f.)
Jania sp. (f.)
Rhizoclonium tortuosum (r.)
Cystophora torulosa (r.)
Dictyota dichotoma (r.)
Dictyota ocellata (r.)
Aphanocladia delicatula (l. ab.)
Splachnidium rugosum (r.)
Gigartina chapmanii (o.)
Liagora harveyana (f.) (summer only)
Calothrix pilosa (l.)

ab. = abundant; f. = frequent; o. = occasional; r. = rare; l. = locally.

Sublittoral Brown Kelp Formation

5. **Carpophyllum–Ecklonia association**

This was not studied in any detail but the upper limit of the association was established. The dominant species are *Carpophyllum maschalocarpum, C. plumosum,* and *Ecklonia radiata.*

FRESHWATER SEEPAGE COMMUNITY

There are one or two places where there is a steady trickle of fresh water over the surface of the rocks near high water mark. In such places a characteristic vegetation has developed dominated by *Entermorpha compressa* f. *subsimplex.* A number of species are associated with the dominant and they include *Rhizoclonium hieroglyphicum* (f.), *R. riparium* (f.), *Calothrix scopulorum, Nodularia harveyana, Microcoleus acutissimus,* and *Rivularia polyotis.*[3]

TIDAL PHENOMENA

A temporary tide pole was established at Stanmore and several successive readings of high tides were noted on this pole or on the adjacent vertical rocks. These marks were subsequently levelled with a theodolite and at the same time a series of positions marking the upper and lower limits of the major communities was levelled. The levelled readings of the high tides were then compared with the records from the tide machine in Auckland Harbour, and, after allowance had been made for tides obviously affected by winds, it was found that 5.2 feet on the tide pole corresponded to 8.5 feet on the Auckland Harbour Board datum.

ASSOCIATION LEVELS

When the levels were examined it was found that in the case of the mussel and the *Chamaesipho* species the upper limits on the flat beach rock were lower than those on the vertical faces of the bluff rocks. This eleva-

[3]The author is grateful to Dr. F. Drouet for identification of some of the Myxophyceae.

tion at the bluffs can be accounted for on the basis of splash action. In other words there is a definite splash zone at the bluffs of nearly 1 foot (see Table 1). Other species are apparently not so affected in this way.

One very interesting point that emerged from this survey was that in general there is a far wider range of values for the upper limits of species than for lower limits, and it therefore appears that the lower limits are more rigidly controlled than the upper limits.

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STEPHENSON, T. A. 1939. The constitution of the inter-tidal fauna and flora of S. Africa. I. *Linn. Soc. London, Jour., Zool* 40: 487–536.

TABLE 1

VERTICAL RANGE OF SPECIES AT STANMORE BAY

SPECIES	LIMITS	AVERAGE*	HEIGHT DUE TO WAVE ACTION*	RANGE*
Volsella neozelanicus . . .	upper	9.49	10.19	8.2 –11.78
	lower	6.58	.....	6.34– 6.76
Chamaesipho spp.	upper	9.39	10.24	8.2 –11.78
	lower	6.71	.....	6.66– 6.76
Saxostrea glomerata	upper	7.44	.....	6.76– 8.13
	lower	5.56	.....	.....
Vermilia carinifera	upper	6.26	.....	5.39– 7.07
	lower	5.56	.....	.....
Corallina, Hormosira, Leathesia	upper	5.19	.....	4.8 – 6.27
Elminius plicatus	upper	8.59	.....	.....
Liagora harveyana	upper	4.29	.....	.....
Codium adhaerens	upper	5.29	.....	5.14– 5.47
Carpophyllum spp.	upper	2.53	.....	2.24– 2.82
Cystophora torulosa	upper	4.04	.....	.....
Ecklonia radiata	upper	2.07	.....	2.24– 2.29

*Admiralty datum. All measurements in feet.

NOTES

The Crab Parasite *Sacculina* in the Fiji Islands

On March 18, 1949, through the kind help of Mr. Harold Gatty at Suva, I obtained the opportunity to collect corals on the reefs near Tomberua Island on the east side of Viti Levu, the main island of the Fiji Group. In addition to other material I found two specimens of the crab *Xantho exaratus* (H. Milne Edwards) which were infested with the parasite *Sacculina leptodiae* Guérin-Ganivet.

The parasites have the broadly oval shape which seems to be characteristic of the specimens living on *Xantho exaratus* (cf. Fig. 1*a-d* in Boschma, H., *Zool. Medea.* 30(3): 49–71, 21 figs., 1948); their greater diameter is approximately 6 and 5 mm. They are attached to hosts which have a carapace breadth of 13.5 and 11.5 mm. respectively.

In shape and size the excrescences of the external cuticle of the mantle do not differ from those of specimens found on the same crab from other localities. In the larger specimen these excrescences have a length of 35 to 45 μ (Fig. 1, upper row); in the smaller specimen they have a length of 30 to 40 μ (Fig. 1, lower row).

Sacculina leptodiae was described by Guérin-Ganivet (*Trav. Sci. Lab. Zool. et Physiol. Marit. Concarneau* 3(7): 1–97, 1911). His material came from the Gulf of Aden and from the Comoro Islands in the Mozambique Channel. Other specimens on *Xantho exaratus* are known from Zanzibar, the Red Sea, and the Andaman Islands. In the East Indies the parasite is of common occurrence on the crabs *Thalamita stimpsoni* A. Milne Edwards and *Pseudozius caystrus* Adams & White (Boschma, loc. cit.). The occurrence of the parasite in the Fiji Islands considerably extends its known range of distribution.

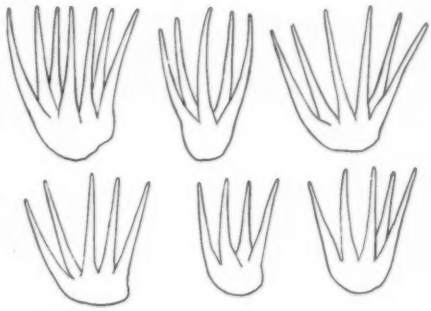

FIG. 1. *Sacculina leptodiae* Guérin-Ganivet: specimens from Tomberua Island, Fiji. Excrescences of the external cuticle of the larger specimen (upper row) and of the smaller specimen (lower row). × 530.

Until now there was only one record of a rhizocephalan parasite in the Fiji Islands, viz., that of specimens of the genus *Thompsonia* on the snapping shrimp *Alpheus malleodigitus* (Bate), obtained by the "Challenger" Expedition on the reef of Levuka, Ovalau Island, east of Viti Levu (Bate, C. S., *Rept Sci. Results Voyage H. M. S. Challenger, Zool.* 24. xc + 942 pp., xv + 76 figs., 157 pls.).—*H. Boschma, Rijksmuseum van Natuurlijke Historie, Leiden.*

On the Supposed Occurrence in New Zealand of the North Pacific Fish Genus *Sebastodes*[1]

While attending the Seventh Pacific Science Congress in New Zealand I presented a paper on what I proposed to call the "antitropical" elements in the marine faunas, using this generalized term to include what I have for some time been calling "pantemperate" as well as what has long passed under the rather misleading term "bipolar." Many patterns of antitropical ranges were indicated. My interest was consequently excited when, shortly afterward, I encountered two specimens in the Dominion Museum at Wellington that were labelled *Sebastodes maccullochi* Phillipps. If the genus *Sebastodes* should be found to occur also in New Zealand, we would have another example of antitropicality of a rather unique type. This large genus, except for one species or species group that ranges from Peru to South Africa, is strictly confined to the two sides of the North Pacific.

An examination of the somewhat complicated evidence indicates, however, that we do not have a new case of antitropical distribution. The specimens that I examined are referable to a well-known New Zealand species that cannot be included in *Sebastodes*. Nor do they represent the species that was described as *Sebastodes maccullochi* by Phillipps (*New Zeal. Inst., Trans. and Proc.* 58: 127–128, pl. 3, fig. 2, 1927). Nor is that nominal species properly referred to *Sebastodes*. The type description and figure call for its reference to the genus *Helicolenus*. Although that genus is essentially pantemperate, a new example of antitropical distribution is not provided since *Helicolenus percoides* (Richardson) has long been recognized as a member of the faunas of New Zealand and Australia.

All characters evident in the description and figure of "*Sebastodes maccullochi*" agree with *Helicolenus* as currently defined, for instance by Barnhart and Hubbs (*Calif. Univ. Scripps Inst. Oceanography, Bul.* 5: 373–377, 385, 1946). There are only 12 dorsal spines (13, rarely 14, in *Sebastodes*) and 5 anal soft-rays (typically 6 to 9 in *Sebastodes*). The dorsal fin begins well backward on the nape, far behind the eye, and is not very deeply notched between the spinous and soft-rayed parts. The spines are not markedly elongated. The pectoral fin has a relatively narrow base, for the lower rays are not procurrent. Some of the upper pectoral rays are branched (not simple as in *Pontinus*). The body is completely scaled and the head is largely scaled. The lateral line is complete. In the absence of contrary evidence it can be assumed that the palatines are toothed. The head is relatively smooth, without deep caverns and high ridges, and with only moderately developed spines. The suborbital keel, developed anteriorly, is spineless. The border of the orbit is smooth.

Though a final identification should await thorough comparisons of specimens, it may be suggested that *Sebastodes maccullochi* Phillipps is probably a synonym of *Helicolenus percoides* (Richardson), the only species of *Helicolenus* now recognized from New Zealand. The type figure, from a photograph, certainly resembles very closely the drawing of *H. percoides* published by Waite (*South Austral. Mus., Rec.* 2: 162, fig. 266, 1921). Synonymies of that species have been given by Waite and by Phillipps (*New Zeal. Mar. Dept. Fish Bull.* 1: 53, 1927).

I wish to thank Mr. W. J. Phillipps of the Dominion Museum in Wellington for assistance and numerous courtesies.—*Carl L. Hubbs, Scripps Institution of Oceanography (University of California), La Jolla, California.*

[1] Contributions from the Scripps Institution of Oceanography, New Series No. 447.

News Notes

Dr. Hans Pettersson, Director of the Oceanographic Institute, Göteborg, Sweden, and leader, on the **"Albatross,"** of the Swedish Deep-Sea Expedition of 1947–48, returned to Honolulu early in December, 1949, to give a series of lectures under the auspices of the University of Hawaii, the Hawaiian Academy of Science, the Hawaii Chapter of the Society of the Sigma Xi, the McInerny Foundation, and the Hawaiian Botanical Society.

Information has reached us through the Interim Secretariat of the Pacific Science Council that the University of British Columbia, in cooperation with the Defense Research Board and the Fisheries Research Board, is establishing an institute of oceanography. The committee in charge of organizing the institute consists of: Dr. W. A. Clemens, Dr. F. H. Sanders, Dr. J. G. Hooley, Dean H. F Angus, Dr. G. M. Shrum, and President MacKenzie (ex officio). The institute will undertake graduate teaching and research in physical, chemical, and biological oceanography The teaching staff will include Mr. W. M. Cameron, Dr. G. L. Pickard, and Dr. J. P. Tully.

We are further informed by the Interim Secretariat that two modern seismographs have been installed in the South Pacific Area—one in Western Samoa, one on South Island, New Zealand. Two others are ready for installation on North Island, New Zealand.

The following publications of the Natural Resources Section and of the Economic and Scientific Section, General Headquarters, Supreme Commander for the Allied Powers, have been received. Each report includes a list of all the reports previously published, their distribution, and rules for obtaining them.

NATURAL RESOURCES SECTION:

Systematic List of Economic Plants in Japan. [By H. Takeda.] Report No. 121. 83 pp.

Pearl Culture in Japan. [By A. R. Cahn.] Report No. 122. 91 pp., 22 figs., 7 tables.

High-Yield Pulping Processes in Japan. [By Harold R. Murdock.] Report No. 123. 39 pp., 16 figs., 8 tables.

ECONOMIC AND SCIENTIFIC SECTION:

Natural Science Research in Leading Japanese Universities, Part I. Report No. 16. 26 pp., 6 tables.

Abstracting Program: Japanese Scientific Journals Covering the Period December 1941–1948. (Progress Report.) Report No. 19. 13 pp.

Scientific and Technological Societies of Japan, Part II. Report No. 20. 185 pp.

A new map of the island of Saipan and an accompanying *Preliminary Gazetteer of Geographic Names for Saipan* have been prepared by the Geological Surveys Branch, Intelligence Division, Office of the Engineer, General Headquarters, Far East Command.

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